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ABSTRACT

Sixty tenth graders participated in this study of relationships between eye/voice span, phrase and clause boundaries, reading ability, and sentence structure. Results indicated that sentences apparently are "chunked" into surface constituents during processing. Better tenth grade readers had longer eye/voice spans than did poorer readers and exhibited more proficiency at chunking sentence structures into phrases and clauses. All subjects used essentially the same pattern of processing different types of sentences, indicating that ability level was not significant in the proficiency of dealing with right and left embeddings. (Author/AA)

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# THE INTERACTION OF EYE-VOICE SPAN WITH SYNTACTIC CHUNKING AND PREDICTABILITY IN RIGHT- AND LEFT-EMBEDDED SENTENCES

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ERNEST P. BALAJTHY, JR.

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REQUIREMENTS FOR THE DEGREE

OF

MASTER OF EDUCATION

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

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APPROVED: Martin Kling
Martin Kling

Jeffrey K. Smith
Jeffrey K. Smith

Ricardo Otheguy
Ricardo Otheguy

ACTING DEAN: _____
Mary B. Kievit

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# CHAPTER I

# INTRODUCTION

## Background

In a survey of eye movement research in reading, Rayner (1975) claimed that, until recently, researchers were satisfied with conducting mere descriptive studies dealing with gross questions about behavior, a trend that fell in line with the behaviorist emphasis upon studies of observable behavior. In recent years, however, researchers have again become interested in eye movement studies as a method of gaining insight into theoretical issues concerning visual processing during reading. Research design has been constructed not to gather statistical evidence to merely describe eye movement behavior, but rather to find evidence for or against certain theoretical issues of importance to reading research. Though eye movement technology is still lacking in many respects, and indeed can still be described as crude for many purposes, it nevertheless has improved tremendously in sophistication since the turn of the century.

Eye movement research in the area of syntactic processing is one area where advances in eye movement technology, coupled with recent revisions in man's understanding of the structure of language,

are shedding light upon psycholinguistic processes in reading. Goodman (1969) has stated, "Understanding of the reading process must depend upon understanding how language works and understanding how language is used, that is how language and thought are interrelated" (p. 11). The researcher has regrettably few tools with which to objectively investigate these processes. Goodman used the analysis of oral reading miscues as a basic tool for studying the interactions of language and the mind. Others use studies in speech processing to determine how the brain works with syntactic information (e.g., Jarvella, 1971; Fodor and Bever, 1965).

Eye movement and eye-voice span (EVS) research is another method by which the researcher can obtain insight into mind-language operations, a method that has particular significance to the visual process of reading. Some recent studies, many originating from the psychology laboratories of Cornell University, have been designed to investigate the relation between syntactic structure and the movement of readers' eyes. Though the number of investigations in this area is small (less than twenty-five), preliminary findings seem to indicate that two major syntactic factors are influential upon eye movement: predictability and "chunking." Sentences whose structures are more predictable due to their familiarity to the reader seem to allow the reader's eye-voice span to increase, while less familiar sentence structures have a decreased span. Syntactic "chunking" seems to be an internal process by which the reader analyzes syntactic structure. This process is apparently reflected by the eye-voice span, which tends to terminate at the boundaries of structural chunks such as phrases and clauses.

## Purpose

The purpose of this study was to investigate the influences of boundary reading and predictability upon the eye-voice spans of high and low ability readers at the high school level.

## Hypotheses

Five hypotheses were proposed. The first two dealt with the relationship between EVS and phrase and clause boundaries.

1. The eye-voice spans of both high and low ability readers tend to terminate at phrase and clause boundaries.

2. High and low ability readers will have the same mean percentage of EVS terminations at phrase and clause boundaries.

The third was proposed to help relate this study to past research.

3. Mean EVS of high ability readers is longer than that of low ability readers.

The fourth and fifth dealt with the interaction of EVS with different sentence structures.

4. The EVS of both high and low readers is longer in sentences with more predictable sentence structure patterns than in sentences with less predictable structural patterns.

5. EVS of high readers is more responsive to sentence structure than the EVS of low readers, as demonstrated by a greater amount of EVS length adjustment in the high reading group than in the low reading group.

## Importance

Very little research has been done using syntax as a variable in the study of eye movement with average and low ability readers. Predictions forming the hypotheses of this study were largely derived from a few studies dealing with young children, several college-level studies, and one study by Schlessinger (1969) done with adult readers of Hebrew. It was hoped that the findings of the present study, whether or not they indicated great differences in performance on the part of the two sample groups, would provide a clue into the workings of syntactic analysis within the readers' minds, and, in conjunction with similar studies, would contribute to the understanding of this aspect of the reading process.

## Definition of Terms

Eye-voice span: the number of sequential words a reader is able to report after the point at which a stimulus paragraph is removed from sight during oral reading.

Syntax: "The way morphemes are joined together to make larger units--words, phrases, clauses, and ultimately whole sentences" (Pyles and Algeo, 1970, p. 133). In the present study, the distinction between deep and surface syntactic structure was viewed as irrelevant. If, however, a distinction must be made, the syntactic units studied were surface in nature.

More predictable and less predictable sentences: a more predictable syntactic pattern is more likely to be constructed by subjects in a cloze-type test than a less predictable pattern. For

this study, right-embedded sentences were hypothesized to be more predictable and left-embedded to be less predictable, in accordance with findings by Levin and Kaplan (1970) and Levin, Grossman, Kaplan, and Yang (1972).

Boundary reading (or chunking): a hypothesized tendency of visual perception during reading to process sentences according to surface structure phrase and clause constituents.

High and low ability readers: high readers are defined as scoring in the top quartile of their grade in school according to results on the Total Reading Score of the Cooperative English Test, Form 2B, 1960 Revision. Low readers are defined as scoring in the lower quartile on the same test.

Target sentence: a sentence containing either a right- or left-embedding, and appearing in a reading selection. Each target sentence was assigned a predetermined critical point.

Critical point: a predetermined point in a target sentence at which, during oral reading, the reading selection is removed from the subject's view.

## Assumptions

A key assumption in this experiment was that eye movement reflects internal syntactic processing. At face value, this would appear to be a logical presupposition, and indeed, research seems to support it. The exact relation of eye movement to processing is however, not yet fully established. A related assumption was that a shortened eye-voice span indicates that the reader is having difficulty in processing. Since this study tried to procedurally equalize all other

variables, it was assumed that the difficulty involved was syntactic in nature.

Another assumption involved in drawing conclusions from this research was that oral reading essentially involves the same internal processes of syntactic and semantic analysis as does silent reading, and that the results of this study could be generalized to silent reading. It was assumed that oral reading is composed of two related, but distinct, processes, those of silent reading and of speech. In order to read with acceptable intonations, the reader must use his silent reading abilities to gather information to the right of the word which is actually being read aloud. A span is thus created between the word being pronounced and the word upon which the eyes are looking. This span, the eye-voice span, is therefore apparently quite closely related to silent reading processes.

## Limitations

Key limitations to the conclusions that can be drawn from the results of this study include the limitations of technique and of assumptions. The eye-voice span is influenced by many factors other than syntax (legibility of material, figure-ground contrast of printed matter, purpose and attitude of reader, among others), all of which must be taken into account by the researcher and by those who examine his findings. Differences in equipment used and methods of measuring eye-voice span may also influence the results.

## CHAPTER II

## REVIEW OF LITERATURE

The focus of this review is on two areas of psycholinguistic research: syntactic processing and the use of eye movement research to investigate internal syntactic and semantic processes. A brief historical survey of the use of eye movement in reading research introduces the subject. A discussion of the chunk theory of syntactic processing is followed by surveys of eye movement research in the areas of surface chunking and transformational deep structures. The effects of predictability of syntax upon eye movement and the eye movements of high and low ability readers in relation to syntax are also discussed. The review is concluded with a discussion of eye-voice span measurement techniques.

### Historical Development

Since the discovery of the existence of saccades (eye movements) by French oculist Javal (1879), numerous researchers in the field of reading have investigated the relationship of eye movements to internal processes. As early as 1922, some researchers recognized that a relationship existed between the mind, the eye, and the content of a passage being read. Judd and Buswell (1922), two important early eye movement researchers, argued that, "Eye movements are but external

manifestations of an inner condition which is set up in the central nervous system" (p. 21), and that eye movements were related to the reader's attempt to process visual material.

In his survey of eye movement research in reading, Rayner (1975) noted that, after an early interest in such issues as word processing, subvocal speech, information processing during fixations, and other critical theoretical matters, eye movement researchers tended to limit their studies to mere description. During the late twenties until the late sixties, such researchers were interested in eye movement pattern differences between readers and in attempting to train eye movement behavior as a method of improving reading. The relative lack of significance in the results of these studies led to a decline in eye movement research. Noting that there were 40% fewer eye movement studies in reading in 1947-1957 than in 1937-1947, Tinker (1948) concluded:

> It would appear from a survey of the literature that the study of eye movements in reading is to some degree reaching the stage of diminishing returns. Relatively few of the recent experiments deal with fundamental problems....The future of eye movements in reading does not appear to be too promising....What we need now is less activity by dilettantes who are inadequately prepared to see the fundamental problems and unable to design suitable experiments in the field. (p. 229)

Recent years have seen a return to the utilization of eye movement and eye-voice span as tools for investigating processing. Under the assumption that movements of the eye reflect or are related to internal processing, researchers are studying these processes using eye movements. One such area of processing during reading which is under study is syntax.

It is difficult and dangerous to attempt to draw anything but very tentative conclusions from the present handful of eye movement and eye-voice span studies on syntax. Yet, as interest builds for the construction of a thoroughly documented model of the reading process, such studies may provide a key to the internal processes involved in reading. Eye movement measurement is rapidly becoming a more exact science and provides information which is easily quantifiable and totally objective.

Eye movement in reading must not be seen as a constant mechanical movement which is basically unchanging. The eyes move in a flexible pattern which is responsive to the content and structure of material being read. Many factors enter into the reading process which complicate findings. For instance, it is difficult to distinguish between purely syntactic and purely semantic context. In the nature of the case, such a distinction seems to be very difficult, if not impossible. Another factor which may contaminate findings is the physical layout of test sentences: researchers must take into account the fact that this will affect eye movements.

A significant amount of research remains to be accomplished to establish a clear link between the internal syntactic processes during reading and eye movement. Yet, the research that has been done seems to indicate that the understanding of such a link will be of great value to all who wish to better understand the reading process.

## Chunk Theory of Syntactic Processing

Gibson (1965), in describing the progression of a child from spoken to written language, claimed that there are three phases in this process, each of which involves different types of learning tasks. They are:

1. learning to differentiate symbols;
2. learning to decode letters to sounds;
3. using progressively high-order units of structure (p. 317).

The last of these phases is of primary concern to this study. As Gibson pointed out, linguists are in general agreement that a heirarchy exists in language composed of units of various sizes and of differing sophistication. Agreement is not so general, however, on the matter of just what the units and heirarchies are, or on how these are related to the perceptual processes.

Gibson argued that the smallest perceptual unit in written language is not the single grapheme, since there does not seem to be a letter-by-letter sequence of processing during reading. She referred to research which shows that tachistoscopic flashing of a word in a letter-by-letter sequence is far less efficient than the flashing of the complete word. Instead of the grapheme, Gibson (1965) argued that spelling patterns are the basic unit in written English. "The relevant graphic unit is a functional unit of one or more letters, in a given position within the word, which is in correspondence with a specific pronunciation" (p. 329).

In a further study of these grapheme-phoneme correspondence units, Gibson, Pick, Osser, and Hammond (1962) attempted to

substantiate this concept as a valid definition of the reading process:

> The hypothesis advanced is that the reading task is essentially that of discovering higher-order invariants, the spelling-to-sound correlations. These are constants which are presumably discovered by exposure to both the graphic and phonemic stimuli at the same time and in different contexts, so that invariant combinations can be recognized in many different words. (p. 555)

They predicted that skilled readers should be able to visually discriminate letter-groups forming pseudo-words better if they were constructed according to standard English spelling-to-sound correlations rather than if they were not so constructed, or only partially so constructed. Results confirmed these predictions.

If it is true, as these studies seem to show, that the phoneme-grapheme correspondence is the basic unit of written language used in the reading task, it is certainly also true that larger and more complex units also exist. The concept of the "chunk" as a unit of immediate memory was first proposed by Miller (1956). He proposed and offered evidence to support the hypothesis that the informational capacity of short-term memory was limited to a certain number of "chunks" of information ("The Magical Number Seven Plus or Minus Two" was the title of his original article and specifies the typical number of chunks that could be held for immediate recall. A grapheme or phoneme might be considered one chunk, but higher-order levels of chunks also exist, according to Miller. Though no person could be trained to exceed the "magical number," anyone could be taught to enlarge the size of his chunks.

> In order to speak more precisely, therefore, we must recognize the importance of grouping or organizing the input sequence into units or chunks. Since the memory span is a fixed number of chunks, we can increase the number of bits of information that it contains simply by building [i.e., training a subject to have] larger and larger chunks, each chunk containing more information than before. (p. 93)

Simon (1974) contested the "constant capacity in chunks" aspect of Miller's hypothesis, claiming that as the number of information bits in each chunk gets larger, the number of chunks that can be held in short-term memory tends to become smaller. Several studies cited demonstrated this tendency as subjects progressed from one-syllable words to familiar phrases of six to ten words, each of these phrases being considered a chunk. Simon does conclude, however, that "the psychological reality of the chunk has been fairly well demonstrated" (p. 487).

According to Levelt (1970), Miller stated in a 1962 study that the phrase might be the natural unit, or chunk, of speech processing. A number of studies were directed at investigating this possibility, the most promising of which utilized a "click procedure." Researchers superimposed clicks on recordings of continuous speech, then requested subjects to report where they perceived the position of the click to be. Assuming that a true perceptual unit would exhibit a tendency to resist interruption, Fodor and Bever (1965) hypothesized that the subjects would tend to perceptually dislocate the click toward, but not beyond, major syntactic boundaries. They found that their hypothesis predicted the direction of click dislocation in 66% of the erroneous responses. Of the total responses, 80% were errors. Bever, Lackner, and Kirk

(1969) criticized this study for dealing only with surface structural boundaries. Their own study was designed to test whether the click procedure pointed toward the existence of underlying structural units in sentences where the surface clause boundaries did not coincide with the underlying structural divisions. Results indicated that the subjective report of click location tended to be attracted toward underlying structural boundaries when they coincided with major surface boundaries, such as subject noun phrases and object noun phrases.

A further study by Bever, Kirk and Lackner (1969) on the psychological reality of linguistic segments utilized galvanic skin response (GSR) to shocks administered during continuous speech. GSR seemed to be related to clause structure, as response was larger at the end of a clause than at the beginning, and the response to shocks at the end of clauses decreased as a function of the clause length.

In another attempt to investigate syntactic segmentation, Levelt (1970) tape-recorded sentences and added a background of white noise. Subjects were asked to write down as much as they heard. Levelt found that large speech-perceived chunks tended to be the same as the major phrase and clause surface constituents, but that no apparent relation existed between the minor chunks and minor constituents.

Some research involving short-term memory and syntax in connected speech has also indicated that syntactic structural units may have an influence on memory. Jarvella (1971) and Jarvella and

Herman (1972) had subjects listen to long passages of connected discourse. The passages were interrupted to test the subjects' recall of the speech. Findings indicated that sentences are processed clause by clause, for a high percentage of listeners were able to exactly recall only the most recently heard clause. Recall of previous clauses and sentences indicated that they had already undergone semantic analysis and the exact wording was forgotten.

Clearly a great deal of research remains to be accomplished in determining the exact role of chunking of linguistic input. The actual psychological reality of such chunks appears to be well established by a number of experimental techniques, but the exact role of these syntactic units is yet to be determined. Further research is also needed in determining heirarchies involved in this linguistic chunking process.

## Syntactic Chunking and Eye Movement

An area of syntactic influence on eye movement in which researchers have done a significant amount of study is that of phrase and clause boundaries and their relationship to eye movement and eye-voice span. Such research promises to be of great value in investigating such theories as that of Gibson (1965), who proposed that maturation in use of language is a process in which a child uses progressively high-order units of syntactic and semantic structure.

Judd and Buswell (1922) theorized that readers frequently slowed down rate of reading in order to group a difficult sentence

into meaningful phrases. They were able to point to several examples from their studies which may have been illustrations of this, but no systematic attempt was made to analyze this any further.

Much of the work in the study of eye movement and syntactic boundaries has been done at Cornell University, and representative studies are found in Levin and Williams (1970). Kennedy (1967), for example, studied regressive eye movements across various types of intra-sentence boundaries. He found that regressions (backward eye movement) tend to take place within, rather than across, such boundaries, and that the stronger the boundary, the less likely a regression will cross it. Weak constituent boundaries (such as that between an adjective and the noun which follows) are much more likely to be crossed than a strong boundary (such as that between a subject phrase and a predicate phrase).

In a study designed to examine eye-voice span in active and passive sentences, Levin and Kaplan (1968) scored their results for the tendency of eye-voice span to end at syntactic boundaries. They found this tendency to be highly significant, as 361 out of 563 eye-voice span recordings terminated at a major boundary. A later study by Levin and Kaplan (1970) used active sentences, variously constructed of two word phrases, three word phrases, and four word phrases. With all three types of sentences, subjects (consisting of 2nd, 4th, 6th, 8th, 10th graders and adults) showed a tendency for eye-voice span to terminate at phrase boundaries. Since there was no difference in number of eye-voice span terminations

at boundaries between the three types of sentences, this result could not be simply explained away as a function of phrase length. Further, "when readers inserted words into their spans that were not really in the text, these insertions usually completed phrases" (pp. 123-124).

Schlessinger (1969), agreeing with Gibson that readers tend to chunk sentences into phrase units, predicted that these chunks, or units, of reading would be determined by the grammatical structure of the sentence. Readers, in attempting to segment the sentence, would read ahead to the end of a group of words which constituted such a syntactic unit. Thus, the eye-voice span would reveal the "unit of decoding," since the syntactic structures themselves would determine the size of the span.

This concept of the eye-voice span as a flexible mechanism, increasing or decreasing according to the dictates of grammatical structure, was supported by Schlessinger's own findings that readers tend to read ahead to the end of phrases. Working with Israeli students in the Hebrew language, Schlessinger constructed sentences similar to the following:

"The woman teacher, who had taught him Latin, was very pleased." He reasoned that reader's eye-voice spans would tend to end at major syntactic boundaries, such as after "teacher," "Latin," and "pleased," as well as at minor syntactic boundaries. These minor boundaries, which Schlessinger calls "chain boundaries," are sentence constituents which "being ignorant of the subsequent words, /the reader/ might take to be the last word in a syntactic constituent" (p. 29).

"Woman" and "him" would be chain boundaries in the example sentence. The results of the study showed that the readers' eye-voice spans tended to terminate at boundaries two-thirds of the time, significantly above the one-half result dictated by chance (since one-half of the words were at such boundaries).

A further study by Levin and Turner (1968) also supported this concept that a reader's eye-voice span is not fixed, but expands and contracts with phrase boundaries. The researchers measured eye-voice span in sentences with active or passive verb phrases. They found that the eye-voice span of mature readers expanded with passive phrases and contracted with active phrases, but that in both cases the eye-voice span tended to terminate at phrase boundaries.

A more recent article, by Rode (1974), noted that "children in the acquisition stage of the /reading/ process appear to be much more constrained than adults in their ability to use conceptual or linguistic cues to guide their reading" (p. 126). Rode's study was designed to examine the ability of children in the acquisition stage to use syntactic cues in the form of phrase and clause boundaries. While her study was primarily concerned with the developmental aspect of use of these syntactic units, it did demonstrate that readers as young as third graders tend to read in phrase units, and that fifth graders show an increasing tendency to terminate eye-voice span at clause boundaries.

It seems apparent that the eye movement studies cited above, as well as several studies involving auditory perception and syntactic chunk boundaries, do not require explanations of syntactic

processing offered by transformational grammar theory. Thus, the chunking model of syntactic processing, which does not require the use of a distinction between deep and surface structure, is rapidly gaining support from researchers, despite the fact that for some years transformational generative grammar has been the accepted approach of many linguists to the mental processes involved in dealing with sentence structure. Future research in eye movement may well prove to be of vital importance in this controversy.

## Transformational Grammar and Eye Movement

Despite the acceptance of transformational generative grammar among linguists during the 1960's, very little work has been done correlating transformations ("those processes which convert deep structures into intermediate and/or surface structures," Jacobs and Rosenbaum, 1968, p. 23) to eye movement or eye-voice span. The theoretical foundation for such studies has been laid, however, and several important auditory perception studies have been done in this area.

In an important theoretical work which attempts to deal with the relation of perception to transformational syntactic structure, Bever (1970) proposed a model of speech perception.

| ACTUAL SEQUENCE | PERCEPTUAL DEVICE | INTERNAL STRUCTURE OF SENTENCE |
|---|---|---|

The stimulus sentence is analyzed by an auditory perceptual device which "isolates the internal structure corresponding to each lexical sequence" (p. 288), that is, breaks the sentence into its constituent intermediate and deep structures. The process of syntactic analysis continues until the sentence is broken down to its deep, or semantic, structure, "the form in which sentences are understood and memorized" (p. 287).

The operation of the perceptual device is of consequence to auditory perception and eye movement researchers. Preliminary research was carried out under the working hypothesis that the perceptual device involved in auditory perception would be directly related to the number of transformations involved in the surface grammatical structure of a stimulus sentence. For example, according to this hypothesis, a passive sentence would be more difficult to understand than an active sentence due to the extra transformation involved in passive constructions. This difficulty would be evidenced in investigations into the perceptual device working to analyze the sentence into its constituent structures. Fodor and Garrett (1966) reviewed the evidence for such claims and concluded that it was unconvincing. They argued that this relationship between grammatical rules is "abstract" rather than direct. Pearson (1975), also pointing out that auditory perception studies simply do not support the hypothesis that "as surface structure form approaches deep structure form, comprehension is facilitated" (p. 158), rejected the transformational generative theory of language and opted for the "chunk" model discussed earlier in this paper, a model he labelled "Conceptual Abstraction."

One key study in auditory perception based upon transformational grammar was done by Fodor and Bever (1965). The researchers constructed stimulus sentences such as the following:

"That he was happy was evident from the way he smiled."

The sentences were then segmented according to the rules of transformational grammar into their deep constituents, as follows:

| | |
|---|---|
| "that he was happy" | "evident from the way he smiled" |
| "he was happy" | "from the way he smiled" |
| "was happy" | "the way he smiled" |
| "was evident from the way he smiled" | |
| "the way" | "he smiled" |

In an effort to find whether these segments are related to perceptual units utilized by listeners, the investigators attempted to find whether the units would resist interruptions, thereby preserving their integrity. Fodor and Bever theorized that if these were actually units, a subject, upon hearing a click placed inside one of these units, would tend to perceptually move the click toward the end of the unit. This procedure was originated by Ladefoged and Broadbent (1960) in an investigation of phones as speech perception units.

The researchers found that the subjects subjectively moved the click (by reporting its occurrence during listening to a sentence, incorrectly as far as placement in the sentence is concerned) toward major transformational unit boundaries in only 53% of the responses recorded, not a particularly important figure. The only syntactic boundaries which were demonstrated to be significant by this study were boundaries between clauses.

The result of this study was a factor in Fodor and Garrett's (1968) rejection of the hypothesis that study of perceptual units would confirm a direct relation between perception and the rules of transformational grammar.

Mehler, Bever and Carey (1967) investigated the relation of surface and deep structure constituents to eye movement. The researchers constructed ambiguous sentences, the interpretation of which differed primarily at the surface phrase structure level (e.g., "they gave her dog candies...") or the deep structure level ("the shooting of the hunters...") or both levels ("they are surprising authors..."). An optical apparatus was used to obtain eye fixation patterns for each sentence. It was found that for the sentences with surface structure differences, noticeable differences existed in the fixation patterns. No such large differences were evident for the sentences with only deep structure ambiguities.

From these rather meager findings, it is apparent that no direct relationship has yet been established between the syntactic analysis proposed by the transformational generative linguists and eye movement. If anything, eye movement and speech perception data seem to demand a different theory altogether. More research is needed specifically designed to probe the link between perceptual chunking and its relationship to internal processing and the structure of language.

## Predictability and Eye Movement

A question of major importance in the study of eye movement and syntactic constraints deals with differences in readers'

strategies in dealing with different types of sentences. How, for instance, do the eye movements or eye-voice span of a reader encountering a passive sentence differ from those of the same reader dealing with an active sentence? Even more importantly, why are the eye movements different or similar?

A major point to have come out of recent eye movement studies is that predictability of a syntactic structure influences eye-voice span. Stated directly, eye-voice span appears to be longer when the reader is dealing with syntactic structures which are more familiar to him and about which he can make certain predictions, than with those which are less familiar and, therefore, less predictable in structure and content.

In a preliminary test to examine this hypothesis, Levin and Kaplan (1970) gave subjects a series of sentences with right-embedding (relative clause modifies the object of the main verb; e.g., "The girls saw the child that Bill teased on the picnic.") or left-embedding (relative clause modifies the subject; e.g., "On the picnic the girls that Bill teased saw the child."). Each embedded clause was deleted and a blank left in its place. The subjects were told to fill in the blanks so as to form a grammatical sentence. The subjects filled the blanks to the right of the verb with embedded clauses 70% of the time; to the left of the verb 33% of the time. The researchers concluded that right-embedding is more often expected than left-embedding, and that, as a result, eye-voice span would be longer in the region of embedding after a main verb. Tests to determine the validity of this hypothesis showed that, indeed, eye-voice span was an average two

words greater with the more predictable right-embedding than with the left.

A further similar study by Levin, Grossman, Kaplan and Yang (1972) also indicated that right-embeddings are more expected than left-embeddings. Seventy-eight percent of the responses to a cloze-type test were right-embeddings, while only 33% were left-embeddings. The experimenters went on to obtain eye-voice span measures at five critical positions (i.e., black-out points, signified in example sentences here by slashes) with each of three sentence types: sentences with left-embeddings (e.g., "After the delay/the visitors/ that/the guard/escorted met/the aide from the office of the governor."), sentences with right-embeddings ("The butcher/chose/the meat/that/the cook/put in the bottom of the freezer."), and sentences with right-embeddings with an introductory phrase similar to that of the left-embedded sentences, used as a check against possible contamination of results due to placement of critical position ("On the trip/the bump/jarred/the furniture/that/the movers carried in the back of the truck."). Results indicated that eye-voice spans in right-embedded sentences were longer than in left-embedded from the second critical position through the fifth, and that the introductory phrase did not affect the span, indicating that placement of the embedded phrase does not appear to be a relevant factor.

In a second experiment, the researchers expanded the number of critical positions to eight and again found differences in eye-voice span to be significant in the region of embedding.

In an eye movement study dealing with right- and left-embedded sentences, Wanat (1971) measured duration and number of fixations.

He found that the time spent on the less predictable left-embeddings was significantly greater than that spent on right-embeddings. Wanat concurred with the research already cited that this greater amount of visual attention was evidently due to the left-embeddings being less predictable structures.

Research on syntactic predictability and eye movement has also been carried out with active and passive constructions. Clark (1965) had found that the latter parts of passive sentences (the subject and verb) were highly constrained by the beginning of the sentence (the object), thus making the end of passive sentences relatively highly predictable. Active sentences were found to have relatively independent beginnings and endings: their second sections (verb and object) were not highly predictable from their first sections (the subject).

Levin and Kaplan (1968) hypothesized from these findings that the eye-voice span should increase in the middle of passive sentences because of the higher predictability and that no increase should be noted in active sentences. Paragraphs were constructed with test sentences embedded in them:

Passive: "The cute chubby boy was slowly being wheeled by the maid along the narrow lane to the country store."

Active: "The brash tall man was certainly being loud at the meeting of the new group on the main campus." (p. 253)

Both passive and active sentences had structurally identical first halves. Critical "light-out" positions were chosen. Findings supported the hypothesis, as eye-voice span in passive sentences grew

longer at the critical positions located at the verb, the positions where a reader would first realize he was dealing with a passive construction. The eye-voice span in the active sentences remained constant.

Although Wanat (1971) found that active sentences required slightly less visual attention than passive sentences, his findings corroborated those of Levin and Kaplan.

> In almost all areas of the sentence, the active score [i.e., duration and number of fixations] is lower than the corresponding passive score....In those areas where the structure of the passive form is more predictable than the active [i.e., the middle, or verb], the passive requires less visual attention. (p. 55)

Wanat found that "taken as a whole, the active is processed somewhat more smoothly than the passive" (p. 54). His conclusion was based on a slightly larger number of regressive eye movements in passive sentences.

From the above findings, it appears that the passive construction, as a less familiar sentence form, requires slightly more visual processing than the active, except in the area of the main verb, where the reader is able to increase eye-voice span due to the constraining powers of the object on the subject. These seemingly contradictory findings clearly call for more research on this subject.

Wanat and Levin (1968), experimenting with agent-deleted (e.g., "The boat was piloted by the harbor.") and agent-included ("The boat was piloted by the helper.") passive sentences, found that eye-voice span is greater with the agent-included sentences. They reasoned that this was due to the fact that agent-included sentences are clearly more familiar and predictable to speakers of English.

Wanat's (1971) eye movement studies extended this investigation and again found that:

> Sentences containing phrases whose structure is more predictable by the sentence context [i.e., agent-included] require less visual attention than sentences containing phrases whose structure is less predictable. (p. 55)

Agent-deleted passives were found to have more regressive fixations than agent-included, though both had an equal number of forward fixations.

Clearly findings considered here indicate that eye movements are heavily influenced by predictability or lack of predictability involved in specific syntactic constructions. A significant amount of further research is needed to clarify certain findings involved in passive and active constructions, however, as well as to extend our knowledge concerning various other, hitherto ignored, sentence patterns and their effects on eye movement.

## Eye Movement of High and Low Ability Readers and Syntax

Although a larger amount of research has been accomplished to compare the eye movements of high and low ability readers, very little has been done using syntax as a variable. Since eye movement may be a key to our understanding of the visual perception process in reading insofar as syntax is concerned, and since a faulty syntactic understanding may be the cause of (or at least a factor in) certain cases of poor reading ability, it would seem important to survey the work that has been done.

Mackworth (1972) recorded the eye movements of high and low ability readers in the second, fourth, and sixth grades undergoing a "fill-in-the-blank" test. Six single word alternatives were given for each blank. He found that low readers spent more time than high readers looking at possible answers which were grammatically unsuitable (e.g., looking at a verb when a noun is needed). He concluded that low readers are not as aware of syntax as high readers. This conclusion was hardly surprising and could have been obtained by a standard test of syntactic knowledge without the eye movement camera.

In a study discussed previously, Schlessinger (1969) tested high and low readers for the tendency to terminate eye-voice span at syntactic boundaries. This tendency was found to exist at approximately the same rate for each group.

The field remains otherwise open as far as eye movement, syntax, and high and low ability readers are concerned. Perhaps further investigation will show syntax as reflected by eye movement to be a relatively unimportant factor in the study of differences between high and low readers. More likely the eye movements of remedial readers will be found to react to syntax in a fashion similar to that of younger or beginning readers.

## Eye-Voice Span

Use of the eye-voice span (EVS), the number of consecutive words a subject is able to say after visual presentation of reading material has been obliterated, has been a familiar technique of eye movement

measurement for many years. Classic studies using this technique, such as Judd and Buswell (1922) and Fairbanks (1937), are familiar to almost everyone acquainted with the field of reading.

In more recent years, this simple technique has not been discarded completely in favor of more sophisticated technology. Instead it has been used as a valued tool by researchers, especially in the area of syntactic processing. Eye-voice span measurements have shown that eye movement in reading is not a constant mechanical movement which is basically unchanging. Instead, the eyes move in a flexible pattern which is responsive to the content and structure of material being read. The EVS is especially responsive to sentence structure and seems to be an indicator of ease in internal processing.

The standard classroom technique of administering an EVS measurement is by manually covering the reading selection with a piece of cardboard or file card. More exact methods suitable for research include the rear screen projection technique (Levin and Kaplan, 1968), the spring-box technique (Neisser, 1963), and the two-way mirror technique (Rode, 1964). The first method involves the projection of a reading selection upon a ground glass rear projection screen similar to those used in microfilm readers. The experimenter obliterates the visual presentation by simply switching off power to the projector light. The spring-box developed by Neisser contains the reading selection printed on a card inside the box. At the desired critical position, the experimenter flips a switch to cover the selection with a spring-powered lid. Rode's two-way mirror box allowed the reading selection to be seen through a two-way mirror

when a light inside the box was turned on. Turning off the light immediately removed the selection from sight.

One of the finest modern studies utilizing EVS was performed by Levin and Kaplan to determine whether EVS was affected differently by active and passive constructions. The following list of technical concerns in EVS measurement is drawn primarily from that study:

1. Target sentences (the sentences in which blackout of the stimulus is to occur) must be properly constructed so that only one variable is present. For instance, in the Levin and Kaplan study, target sentences were structurally identical except for passive and active constructions. Vocabulary was also controlled.

2. Target sentences must be embedded in paragraphs of four to five sentences (at least) which are unrelated in content, so that context can give no cues as to the words after the target point.

3. Since studies have shown that subjects tend to scan the first line of a selection before reading aloud, the target sentence must not be first.

4. To insure that subjects do not become conditioned to ignoring the first sentence of paragraphs, filler paragraphs must be constructed in which black-out occurs in the first sentence.

5. To be certain of statistical validity, a large number of paragraphs must be used in different random presentation orders.

6. Preliminary exploratory investigations may be necessary to find the best critical positions.

7. Ample room must be allowed before and after a critical position. Levin and Kaplan allowed at least three words to precede and eight to eleven words to follow the critical position.

8. Size of letters should approximate that in texts.

9. Levin and Kaplan utilized a fixation point, which appeared on the projection screen indicating where each paragraph would begin. This eliminated the problem of the subject having to search the screen every time a new paragraph was exposed, thus allowing time to briefly scan the paragraph and possibly influence the results.

10. Contrast between letters and background should be low enough to prevent visual after-images.

A number of methods of computing EVS exist, none of which has thus far shown any significant difference in quality of results. The standard eye-voice measurement, the number of words after the critical point reported orally, has already been described. Levin and Kaplan (1968) called this the Recall EVS.

They also incorporated another computation, labelled the Recognition EVS, into their study. A list of individual words, some of which were the words following the critical position and some of which were words visually or semantically similar to them, was constructed and administered to the subject after the subject's report of Recall EVS. The subject was instructed to choose any words from the list which were recognized as having been part of the reading selection but which had not been reported. This test was designed as a control for guessing and for the subject being too conservative.

Another EVS computational technique was used by Rode (1974). Called Corrected Scoring, a subject's errors in recall EVS were labelled "miscues" and analyzed as to syntactic and semantic

correctness. Rode found that 62% of the miscues were correct in both areas and used the results to further establish her findings with Recall EVS.

Geyer (1968) measured a temporal eye-voice span, the time needed to pronounce words remembered after the critical point. He found that the temporal EVS tends to remain constant at approximately one second.

Eye-voice span measurement, which for many years was seen by researchers as an outdated instrument of minimal value, is now being used as a variable in the study of such areas as information processing during reading, development of letter perception, and syntactic and semantic processing of sentences. It is apparent that such research, based upon the assumption that externally observable movements of the eyes are a major clue to internal processes, will be a valuable contribution to the formation of theories of reading based upon those processes.

## Summary

At the present time, a great amount of research is still needed to clarify the relation between internal syntactic analysis, and perceptual devices such as eye-voice span measurement in order to determine the value of such devices in the development and support of theories of reading. While it is apparent that eye movement during reading does reflect surface syntactic constituents such as phrases and clauses, even with novice readers, more research of the subject is necessary to confirm the phenomenon, and the present study sought to do so at the high school level.

More importantly, the present study attempted to expand knowledge concerning the external reflection of internal processes involved with the reading of more and less predictable sentences. Previous research in the area, proving to be somewhat contradictory, had failed to clarify the role of predictability of grammatical structure in reading, and it was hoped that this study would clarify some of the issues involved, especially in regards to how higher and lower ability readers would deal with the right- and left-embedded structures.

Lastly, the study recorded and analyzed differences between the high and low ability reading groups when dealing with both syntactic constituents and with more and less predictable sentence structures, with the purpose of determining how each group grappled with the syntactic problems involved.

## CHAPTER III

## METHOD

The primary purpose of the first two hypotheses of this study was to examine the tendency of the eye-voice span of high and low ability high school readers to terminate at phrase and clause boundaries. A second purpose, dealt with in the last two hypotheses, was to determine whether a relationship exists between students' reading ability and their eye-voice span flexibility when encountering more and less predictable sentence structures. The third hypothesis was designed to confirm findings of older studies in regard to the EVS of better and poorer readers. The following questions were asked:

1. Do the eye-voice spans of readers tend to terminate at phrase and clause boundaries significantly more than predicted by chance?

2. Is there a significant difference in tendency to terminate eye-voice span at phrase and clause boundaries between high and low readers?

3. Is there a significant difference in the average eye-voice span of high and low readers?

4. Is there a significant difference in the average eye-voice span for students reading more and less predictable sentences?

5. Is there a significant difference between high and low readers in regard to their adjustment of eye-voice span length between more and less predictable sentences?

## Sample

Manville High School is located in the Borough of Manville, Somerset County, New Jersey, a suburban community composed primarily of blue collar workers who are second and third generation descendents of immigrants from Eastern Europe. There are no black and few Hispanic students in the high school.

The participants in this study were randomly drawn from the upper and lower quartiles of the tenth grade and included 25 girls and 35 boys, a total of 60. Average age was 15 years, 2 months, the range being from 14 years, 4 months, to 15 years, 11 months.

Subjects were chosen and assigned to one of two groups according to their results in the Total Reading subscore on the Cooperative English Test, Form 2b, 1960 Revision. Subjects in the upper quartile were assigned to Group I. Subjects in the lower quartile were assigned to Group II. No students who scored in the middle two quartiles were chosen for this study.

No intelligence test was administered to the subjects, but chronological ages were checked against grade placement to insure that all students were in approximately the expected grade for their age. It was believed that this would adequately insure that both the very low and very high ends of the I.Q. range would tend to be eliminated. It was not believed necessary to administer an intelligence

test solely for the sake of this study, as the study was more concerned with reading achievement than with intelligence *per se*.

## Measurement Instruments

In order to choose subjects and assign them to experimental groups, a normed reading achievement test was utilized. After subjects were randomly chosen from a list of qualified students and assigned to either Group I (high readers) or Group II (low readers), a specially constructed eye-voice span test was individually administered to each student.

### Reading Achievement

#### Description and Reviews.--

The *Cooperative English Test* (1960 Revision), Level Two, is a test designed and normed for grades nine to twelve. It consists of two forty-minute sections, one for reading and the other for English expression. Only the Total Reading subscore results were used in this study.

Reviews of the test appear to be highly favorable. Feldt (Buros, 1965), for instance, "has no hesitancy in strongly recommending" the test (p. 554), as he believed it to be well constructed and statistically very sound despite a need for more research on the predictive validity. Though Lorimer (Buros, 1965) pointed out that the norms are based largely on small rural towns and expresses reservations about a small number of the reading samples, she claims the test is "probably the best on the market" (p. 556).

The reading section of the test is composed of two subtests: vocabulary and reading comprehension. The vocabulary section contains 60 items, each of which consists of a word out of context and four choices of possible synonyms. The reading comprehension subtest also contains 60 multiple choice questions concerning reading selections. The selections vary in length from 60 to 300 words and cover a wide range of subject material.

Raw scores are reported for vocabulary, reading comprehension (which is largely unaffected by reading rate), and the rate of comprehension. By referring to the proper scale in the interpretation manual, the three raw scores can then be transformed into percentile rank bands. A total reading percentile rank band can also be obtained by combining the raw scores of the subtest and referring to the proper scale in the manual.

Alternate form reliability is reported in the technical report as being .94 for the Total Reading Score on Form 2B of the test. Reliability measures for the subscores are also reported: .89 for vocabulary, .78 for comprehension, and .87 for speed of comprehension.

The technical manual provides information on only one study of the predictive validity of the 1960 Revision, which was carried out at the college level. Results on Form 1C administered to freshmen were correlated with results on regular English tests during the following semester and resulted in a .67 correlation. Numerous studies of the predictive and concurrent validity of the earlier forms of the test are also reported, with correlations ranging from the thirties to the low seventies.

Administration of the Cooperative English Test.--

The Cooperative English Test, Form 2B, had been administered to all tenth grade students at Manville High School during the fall of 1976, and the results were in the school files. Results had been obtained using tenth grade spring norms, since the publishers of this test have made only spring norms available. They warn that this may result in a tendency for scores to be somewhat low, but this effect was deemed to be of minimal importance to the present study. The administration of this test was a part of the regular program of the English department, each English teacher giving the test during class time in two fifty-minute periods or three forty-minute periods.

Results of the Total Reading subscore were used to place each student in one of three categories:

1. High readers: those whose raw score results placed them in the upper quartile, according to the norms reported in the test's technical manual.

2. Low readers: those whose results placed them in the lower quartile, according to the norms reported.

3. All other subjects (i.e., those in the middle two quartiles) were disqualified from this study.

From each of the first two groups, thirty students were chosen at random to be subjects. High ability readers were assigned to Group I and low readers to Group II.

## Eye-Voice Span Measurement

### Scan Box.--

A scan box similar to that described by Rode (1974) was constructed to facilitate measurement of eye-voice span. A two-way sheet-plastic mirror was positioned at the top of the wood frame box so that when a small light bulb inside the box was turned on, a small shelf near it became clearly visible through the plastic. With the light off, the contents of the box were not visible. Reading selections were placed on the shelf. When the light was extinguished, the plastic functioned as a mirror and the reading selection was not visible.

After a reading selection was placed in the scan box through an aperture in the back, the experimenter activated a hidden switch to turn on the light. As the subject read the visible reading selection aloud, the experimenter waited until a predetermined critical position in the selection was reached. He then turned off the light, removing the selection from the subject's view. The experimenter then recorded the last word of the reading selection which the subject was able to accurately remember.

### Target Sentences.--

Previous studies, notably Levin and Kaplan (1970), Wanat (1971), and Levin, Grossman, Kaplan, and Yang (1972), discovered that predictability seems to play a key role in the eye-voice span of subjects

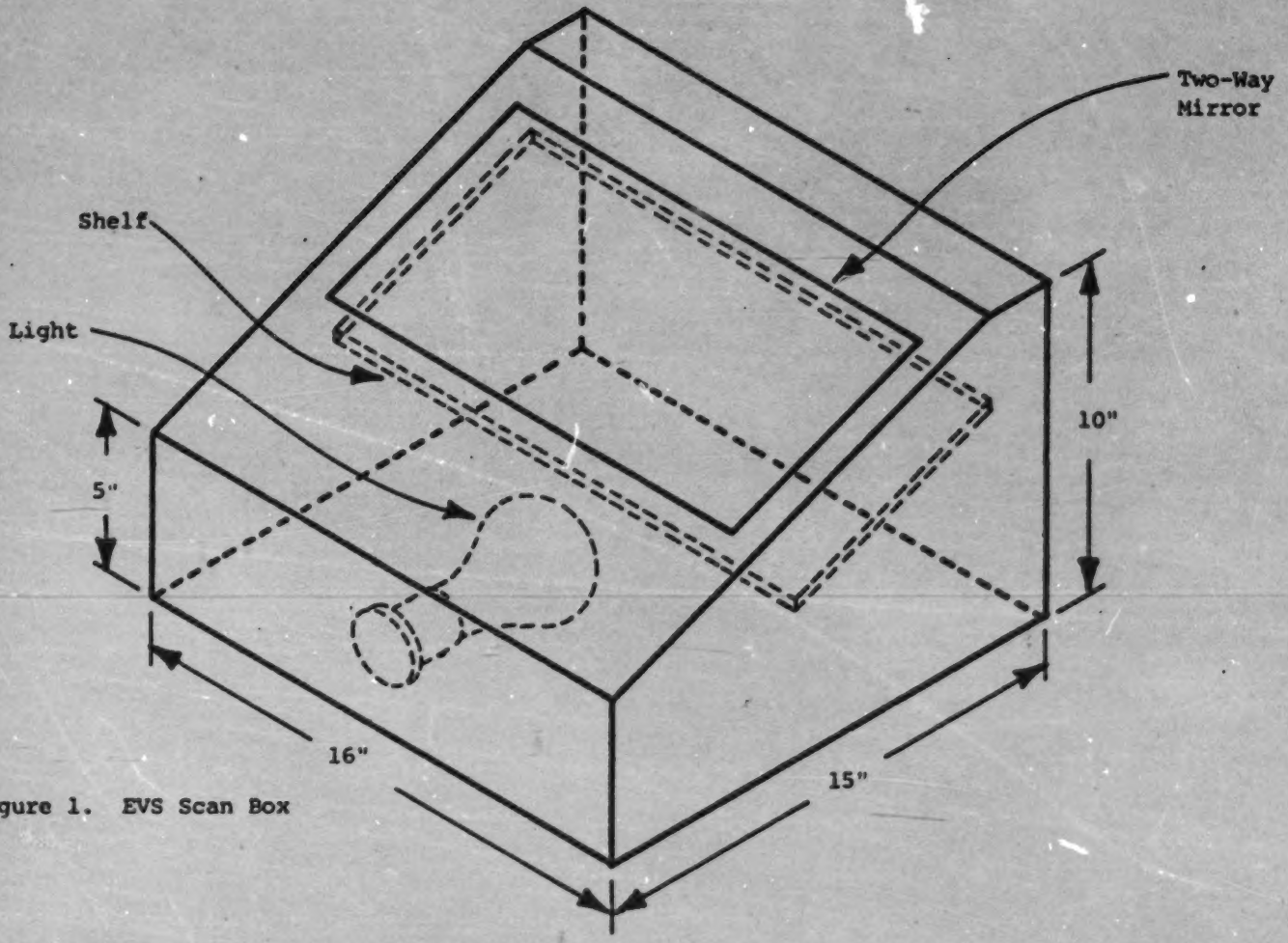


Figure 1. EVS Scan Box

reading right- and left-embedded sentences. It was for this reason that these two sentence structures were chosen to constitute the target sentences.

Twenty sentences of each type were constructed (see Appendix B) for the purposes of this study, with vocabulary simple so that poorer readers would have little difficulty in oral reading. Each target sentence was made up entirely of three word phrases and clauses in order to facilitate statistical treatment of subjects' tendency to terminate eye-voice span on the last word of syntactic structures (i.e., boundary reading). The use of such short phrases and clauses was seen as having little effect on the boundary reading results, as Levin and Kaplan (1970) had previously compared three, four and five word sentence components and had found no qualitative or quantitative differences in tendency to read to syntactic boundaries.

Both right-embedded and left-embedded target sentences were composed to consist of six phrases of three words each. The first part of each type was an introductory prepositional phrase followed by a three word noun phrase containing the subject. Left-embedded sentences then had a restrictive clause modifying the subject, followed by a verb phrase and two prepositional phrases. The right-embedded sentences had the verb phrase positioned immediately after the noun phrase. The direct object in the verb phrase was followed by a modifying restrictive clause, and two prepositional phrases were located at the end of the sentence. In the following examples, the slashes indicate syntactic boundaries as used in this study:

Right-embedded: After being fired/ the discontented
Prepositional Noun
worker/ threatened a foreman/ who was standing/ near the
Verb Restrictive Prepositional
gate/ of the factory.
Prepositional

Left-embedded: After the class/ most of us/ who had
Prepositional Noun Restrictive
attended/ enjoyed a meal/ at the diner/ near the school.
Verb Prepositional Prepositional

Five critical positions, at which the reading selection would be removed from the subject's sight, were chosen. The locations of these critical positions are underlined in the examples above. Four right-embedded and four left-embedded sentences were placed in each critical position group, numbered Critical Position One through Critical Position Five, in order from left to right in the sentence. Each sentence was assigned only one critical position.

Reading Selections.--

A previous study utilizing eye-voice span measurement (Levin and Kaplan, 1968) found that subjects tend to scan the first line of a reading selection before beginning to read it aloud, a factor which would influence the eye-voice span. As a result, target sentences were embedded in selections (see Appendix A) composed of four or five sentences and were never placed at the beginning of a

selection. All target sentences ended at the right margin of the paper so that placement in the line would not become a factor in the eye-voice span measurement. All sentences were unrelated in topic so that the subject's use of contextual clues from previous sentences would not affect his eye-voice span in the target sentence. In order to insure that the subject did not realize that the first sentence of each selection was never the target sentence, filler paragraphs were constructed which contained no target sentence, but in which the scan box light was extinguished during reading of the first sentence. It was hoped that this procedure would lead the subject to pay close attention to each sentence.

Each critical position was preceded by at least three words on the same line and was followed by at least eight words on that line. Levin and Kaplan (1968) had found this amount sufficient to avoid interference with the left-to-right sweep of the eyes across the target sentence. Exploratory investigations performed as a preliminary to this study also found that the above structure did not interfere with the subjects' eye-voice spans.

Selections were typed with pica-sized lettering on white paper which was then fastened to cardboard. Lighting was adjusted so that the print was clearly visible but did not leave an after-image.

A total of forty-five paragraphs were constructed: twenty contained target sentences with left-embedded structures; twenty contained target sentences with right-embedded structures; and five were filler paragraphs with no target sentence. Paragraphs were numbered according to structure: LE 1 having a left-embedded target sentence,

RE 1 a right-embedded target sentence, and F 1 being a filler paragraph. Sentences numbered 1 to 4 were assigned Critical Position 1; 5 to 8, Position 2; 9 to 12, Position 3; 13 to 16, Position 4; and 17 to 20, Position 5.

Two examples of reading selections follow. The critical position in each is underlined, though, of course, it was not underlined in the copy used for testing. Since the actual reading selections were typed on paper which was eleven inches in width, the present margins are insufficient to print complete lines exactly as appeared during the test. Instead, slashes are used to indicate the line divisions.

RE 1

Let's not be unhappy about this. While you're on the tennis court, you should be enjoying life. Rabbits eat only/ plants. After three weeks two German armies attacked American troops who were stationed near the town of Saint Martin./ Some reasons are good, some not so good. If you take up bridge to make new friends, play the game fairly. German/ bombers were doing great damage to English cities, but then radar began to be used to spot enemy planes.

LE 15

My father called Paul and me together. Everyone who passes the entrance examinations may begin college work in/ September. During the film most people there who sat forward missed the argument in the back of the theater./ Why don't you send John

and me copies of this photograph? The fruit from our garden is enough to support the entire/ family for most of the winter. We call Fred, John, Paul and Marty the "Fantastic Four."

The Fry readability nomograph was used to determine the grade level of the reading selections. The average grade level was determined to be 7.0. In a pilot study, when reading selections were found to contain words which proved to be very difficult to the subjects, the reading selection was rewritten with the troublesome word deleted.

Administration of Eye-Voice Span Procedure.--

Eye-voice span tests were carried out during November and December of 1976.

Each subject was seated in front of the scan box and informed by the experimenter about the eye-voice span measurement procedure and the operation of the scan box. The following instructions were then read:

> This procedure is called an eye-voice span test. When I turn on the light inside the box (Turn on light), you will see a paragraph through the two-way mirror. (Turn off light.) Begin reading the paragraph aloud immediately. At some point in the paragraph, I will turn off the light and you will no longer see inside the box. Since most people's eyes travel a little bit ahead of

their voices when reading aloud, you will probably remember some words past the point where the light was turned off. Say them aloud.

There are 35 paragraphs in this procedure. The first three are just for practice. While each sentence will make sense by itself, the paragraphs are made up of unrelated sentences.

In order to familiarize the subject with the procedure and put him at ease, three filler paragraphs were used to begin. Results on filler paragraphs were not recorded by the experimenter. After the completion of the practice paragraphs, the procedure was carried out until fifteen LE and fifteen RE selections were completed. The selections were chosen in random order from the shuffled pile of reading selections.

The experimenter used a spirit duplicated score sheet. The score sheet contained all 40 target sentences, numbered to correspond with the reading selections, and with critical points underlined. The experimenter circled the last consecutive word remembered by the subject after the critical point when the scan box light had been extinguished. He then proceeded to the next reading selection. The entire testing procedure lasted between fifteen and twenty minutes.

## Scoring of Results and Statistical Analysis

A scoring sheet for results was filled out for each subject. Information on the sheet included the subject's assigned number

(Numbers 1 to 30 were in Group I and Numbers 31 to 60 were in Group II.), his Cooperative English Test Total Reading raw score, and his age. Eye-voice span lengths were recorded for both left- and right-embedded sentences at each of the five critical positions. Terminations of eye-voice span at phrase boundaries were marked with a plus sign and all other terminations with a minus.

The following results were tabulated:

1. Average eye-voice span for Group I, Group II and Total Subjects
2. Average eye-voice span for each critical position for both groups and total
3. Average eye-voice span for each critical position of right- and left-embedded sentences for both groups and total
4. Average eye-voice span for left- and right-embedded sentences for both groups and total
5. Percentage of positive terminations for both groups and total
6. Percentage of positive terminations at each critical position.

In order to determine the statistical significance of the hypothesized differences, t-tests were calculated for each hypothesis.

# CHAPTER IV

## RESULTS

### Hypothesis 1

Hypothesis 1 was concerned with whether the eye-voice spans of readers significantly tended to terminate at phrase and clause boundaries.

Mean percentages of EVS terminations at phrase and clause boundaries were calculated for high and low readers and for the sample as a whole. Percentages were calculated for each critical position and at all positions together. These results were subjected to *t*-tests of significance against a chance percentage of 33.3 (since one-third of the possible EVS terminations were at syntactic boundaries). Table 1 lists the results.

As predicted, the EVS of all readers at all critical positions significantly tended to terminate on the last word of phrases and clauses. Terminations at syntactic boundaries accounted for 57.5% of the total terminations. Both Group I and Group II readers exhibited such tendencies to slightly different averages: 60.9% for the high readers and 54.1% for the low readers.

EVS significantly terminated at syntactic boundaries at each critical position for the entire sample of 60 subjects. The mean

TABLE 1

MEAN PERCENTAGES AND *t* VALUES OF EVS TERMINATIONS AT SYNTACTIC BOUNDARIES

| Critical Position | Total Group (N=60) | | | Group I (N=30) | | | Group II (N=30) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean % | S.D. | *t*[a] | Mean % | S.D. | *t*[b] | Mean % | S.D. | *t*[b] |
| 1 | 39.6 | 20.1 | 2.43 | 41.0 | 22.3 | 1.89 | 38.2 | 17.8 | 1.51 |
| 2 | 71.1 | 18.8 | 15.57 | 70.0 | 18.5 | 10.87 | 72.2 | 19.5 | 10.93 |
| 3 | 62.5 | 21.4 | 10.57 | 63.5 | 24.8 | 6.67 | 61.4 | 17.7 | 8.70 |
| 4 | 48.9 | 20.2 | 5.98 | 56.0 | 20.8 | 5.98 | 41.7 | 17.0 | 2.71 |
| 5 | 62.6 | 16.6 | 13.67 | 68.2 | 19.1 | 10.01 | 56.9 | 11.2 | 11.54 |
| All | 57.5 | 10.0 | 31.71 | 60.9 | 10.3 | 14.68 | 54.1 | 8.5 | 13.40 |

[a]For 58 degrees of freedom, a *t* value of 2.00 is needed for the 5% level of confidence.

[b]For 29 degrees of freedom, a *t* value of 2.04 is needed for the 5% level of confidence.

Note. *t*-tests taken for each group at each critical position tested the actual mean EVS percentage against a chance percentage of 33.3.

percentages of such terminations ranged from 39.6% at Critical Position 1 to 71.1% at Critical Position 2.

However, not all results at each critical position were significant. High and low readers considered separately both failed to significantly demonstrate termination at boundaries for Position 1, the first critical position in the target sentences. At each of the four subsequent critical positions, significant chunking was noted.

## Hypothesis 2

Hypothesis 2 was concerned with the possibility of a difference in tendency to terminate EVS at phrase and clause boundaries between high and low ability readers.

In analyzing the significance of differences between the means of Group I and Group II at all critical positions combined, the overall hypothesis that there will be no significant difference between high and low groups in EVS terminations at syntactic boundaries was rejected (Table 2). The mean percentage of EVS termination at phrase or clause boundaries was 60.9% for Group I and 54.1% for Group II, and the *t* value indicated a significant difference between the two groups at the .05 level of confidence.

However, when each critical position was examined separately, three out of the five critical positions showed no difference between high and low readers. In Critical Positions 1, 2, and 3, readers in both groups revealed no significant difference in percentage of terminations at phrase and clause endings. At both Critical Positions 4 and 5, Group I readers showed significantly greater percentages of

TABLE 2

MEAN PERCENTAGES AND *t* VALUES OF DIFFERENCES BETWEEN MEAN PERCENTAGES OF EVS TERMINATIONS AT SYNTACTIC BOUNDARIES

| Critical Position | Group I Percent (N=30) | Group I S.D. | Group II Percent (N=30) | Group II S.D. | *t*[a] |
|---|---|---|---|---|---|
| 1 | 41.0 | 22.3 | 38.2 | 17.8 | .54 |
| 2 | 70.0 | 18.5 | 72.2 | 19.5 | .45 |
| 3 | 63.5 | 24.8 | 61.4 | 17.7 | .38 |
| 4 | 56.0 | 20.8 | 41.7 | 17.0 | 2.91 |
| 5 | 68.2 | 19.1 | 56.9 | 11.2 | 2.91 |
| All | 60.9 | 3.1 | 54.1 | 2.6 | 2.79 |

[a]For 58 degrees of freedom, a *t* value of 2.00 is needed for the 5% level of confidence.

terminations at syntactic boundaries. At Critical Position 4, Group I subjects terminated EVS at a phrase or clause ending an average 56% of the target sentences, compared with 41.7% for the Group II readers. At Critical Position 5, Group I scored 68.2% and Group II, 56.9%.

## Hypothesis 3

Hypothesis 3 was concerned with whether there is a significant difference between the average eye-voice spans of high and low ability readers.

The mean EVS in numbers of words for right-embedded sentences, left-embedded sentences, and all sentences together were calculated for all subjects and for the high and low groups separately. Table 3 presents the t-tests of significance of the difference between sample group EVS means for both types of target sentences and for all sentences. All three t-tests were significant at the .05 level of confidence.

The mean EVS in number of words for Group I readers was significantly longer than the mean EVS for the Group II readers. The mean EVS for Group I was 3.00 words and for Group II, 2.62 words.

Group I readers had longer EVS lengths for both right-embedded and left-embedded sentance structures than did the Group II readers. Mean EVS for Group I was 3.05 words for right-embedded sentences, compared to 2.59 for Group II, and 2.91 for left-embedded sentences, compared to 2.67 for Group II.

TABLE 3

MEAN EVS AND *t* VALUES OF DIFFERENCES BETWEEN SAMPLE GROUPS' MEAN EVS

| Group | Right-Embedded | | Left-Embedded | | All Sentences | |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| All Subjects (N=60) | 2.82 | .45 | 2.78 | .41 | 2.81 | .37 |
| I (N=30) | 3.05 | .46 | 2.91 | .47 | 3.00 | .39 |
| II (N=30) | 2.59 | .28 | 2.67 | .30 | 2.62 | .22 |
| *t*[a] | 4.60 | | 2.38 | | 4.58 | |

[a] *t*-tests of the difference between sample means of Group I and Group II were calculated for right-embedded sentences, left-embedded sentences, and all sentences. For 58 degrees of freedom, a *t* value of 2.00 is needed for the 5% level of confidence.

## Hypothesis 4

Hypothesis 4 was concerned with whether there existed a significant difference in the average eye-voice span of students reading more and less predictable sentences. Results did not support the hypothesis that more predictable (i.e., right-embedded sentences in this experiment) syntactic structures will result in longer eye-voice spans than less predictable (i.e., left-embedded) structures.

In analyzing the mean EVS lengths in words over all critical positions combined (Table 4), no significant difference was found between the mean EVS for right-embedded sentences (2.82 words) and for left-embedded sentences (2.78 words).

However, the mean EVS lengths for each critical position separately (Table 4 and Figure 2) showed that subjects do react differently to the two different syntactic structures.

Critical Position 1: Subjects' mean EVS was significantly longer for left-embedded sentences (mean = 3.03 words) than for right-embedded sentences (mean = 2.76 words). The level of significance was .005.

Critical Position 2: Subjects' mean EVS was again significantly longer for left-embedded sentences (mean = 3.29 words) than for right-embedded sentences (mean = 2.84 words). The level of significance was .005.

Critical Position 3: No significant differences, though left-embedded mean EVS was somewhat longer than right-embedded.

Critical Position 4: Subjects' mean EVS was significantly longer for right-embedded sentences (mean = 2.75 words) than for left-embedded

TABLE 4

MEAN EVS FOR RIGHT- AND LEFT-EMBEDDED SENTENCES AND *t* VALUES OF DIFFERENCE BETWEEN MEANS

| Critical Position | Right-Embedded | | Left-Embedded | | *t*[a] | Significance |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | | |
| 1 | 2.76 | .72 | 3.03 | .79 | 10.76 | .005 |
| 2 | 2.84 | .51 | 3.29 | .71 | 4.02 | .005 |
| 3 | 2.59 | .78 | 2.72 | .64 | 1.00 | NS |
| 4 | 2.75 | .78 | 2.32 | .65 | 3.28 | .005 |
| 5 | 3.24 | .89 | 2.87 | .68 | 2.57 | .01 |
| All | 2.82 | .45 | 2.78 | .41 | .51 | NS |

[a]For 118 degrees of freedom, a *t* value of 1.98 is needed for the 5% level of confidence.

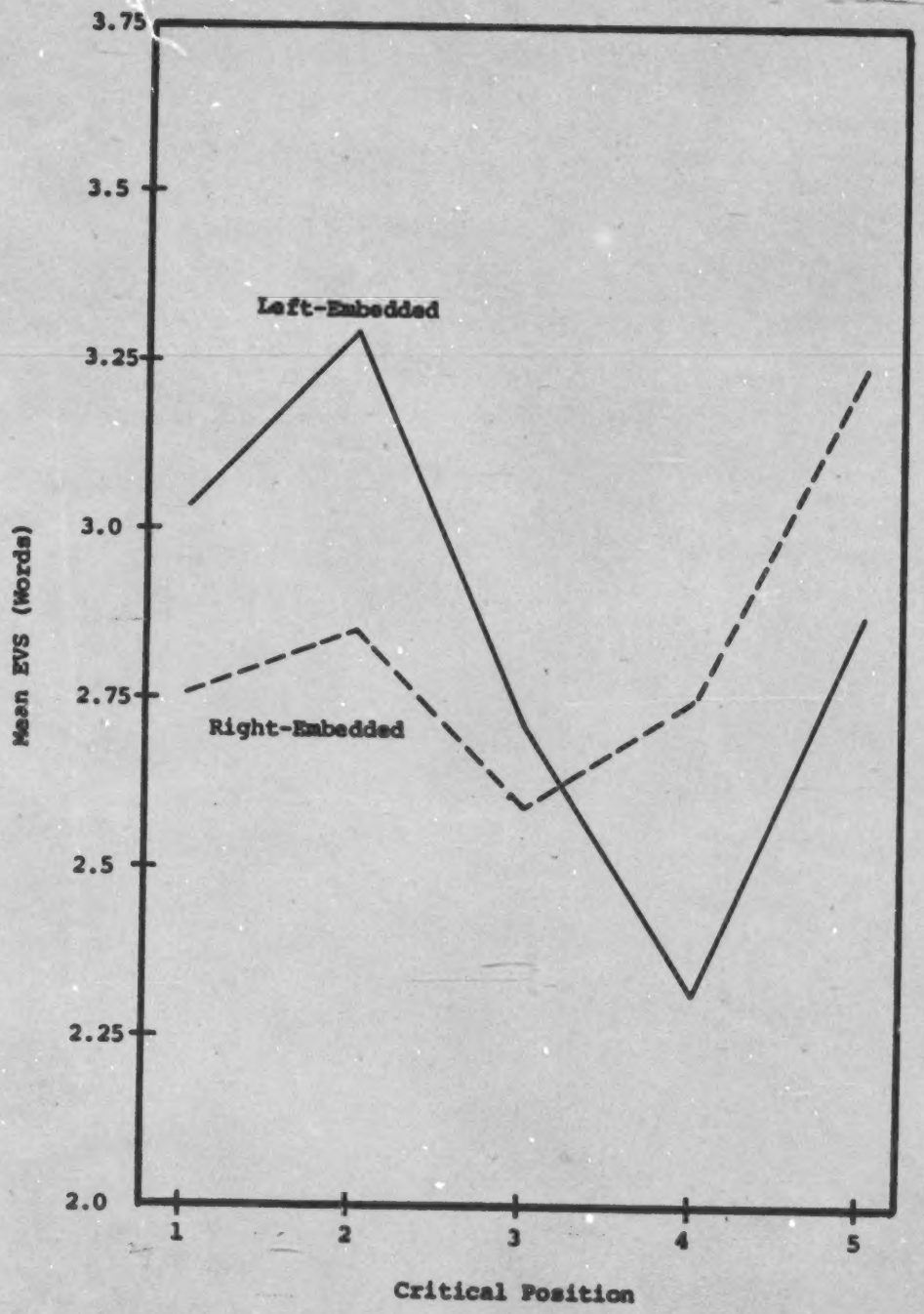


Figure 2. Mean EVS For Right- and Left-Embedded Sentences.

(mean = 2.32 words). The level of significance was .005.

Critical Position 5: Subjects' mean EVS was significantly longer for right-embedded sentences (mean = 3.24 words) than for left-embedded (mean = 2.87 words). The level of significance was .01.

## Hypothesis 5

Hypothesis 5 was concerned with whether a difference existed between high and low readers in the amount of adjustment of EVS between critical positions.

Table 5 summarizes the means and standard deviations of shifts in EVS length by critical position and for all critical positions combined. An examination of the *t* values indicates that there is no significant difference in the adjustment of EVS between critical positions or among all critical positions for each group. For all sentences combined, at all critical positions, the mean total shift in length of EVS for Group I was 6.57 and for Group II, 5.91. The resulting *t* value of 1.110 fell short of the 5% level of confidence. At none of the separate critical positions did the *t* values of differences between groups reach significant levels. This indicates that both groups adjusted EVS in essentially the same manner.

Since the issue of syntactic strategies in analyzing sentence structures was an important one, and since eye-voice span is one possible avenue for performing such analysis, the mean EVS for both Group I and Group II was obtained for each critical position in each of the sentence structures, as shown in Table 6. Figure 3 presents

the results for right-embedded sentences, and Figure 4 for left-embedded sentences. Group I and Group II readers apparently varied the length of their eye-voice spans in parallel fashion, with variation depending upon the type of sentence more than upon the ability to read.

TABLE 5

MEAN SHIFTS IN EVS BETWEEN CRITICAL POSITIONS

| Sentence Type and Critical Position | Group I EVS Shift (in words) | | Group II EVS Shift (in words) | | $t$[a] |
|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | |
| Right: 1--2 | .63 | .62 | .53 | .51 | .685 |
| Right: 2--3 | .78 | .41 | .82 | .56 | .316 |
| Right: 3--4 | .91 | .66 | .65 | .54 | 1.670 |
| Right: 4--5 | 1.10 | .80 | .81 | .73 | 1.469 |
| Left: 1--2 | .82 | .59 | .75 | .52 | .487 |
| Left: 2--3 | .94 | .55 | .95 | .70 | .062 |
| Left: 3--4 | .59 | .47 | .46 | .53 | 1.008 |
| Left: 4--5 | .67 | .75 | .70 | .59 | .172 |
| Right: All | 3.42 | 1.46 | 2.90 | 1.77 | 1.240 |
| Left: All | 3.09 | 1.68 | 3.02 | 1.23 | .185 |
| All: All | 6.57 | 2.34 | 5.91 | 2.27 | 1.110 |

[a]For 58 degrees of freedom, a $t$ value of 2.00 is needed for the 5% level of confidence.

TABLE 6

MEAN EVS FOR RIGHT- AND LEFT-EMBEDDED SENTENCES
BY CRITICAL POSITION

| Critical Position | Right-Embedded | | | | Left-Embedded | | | |
|---|---|---|---|---|---|---|---|---|
| | Group I | | Group II | | Group I | | Group II | |
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| 1 | 3.01 | .83 | 2.51 | .49 | 3.19 | .92 | 2.88 | .61 |
| 2 | 3.03 | .38 | 2.65 | .54 | 3.43 | .69 | 3.15 | .71 |
| 3 | 2.79 | .87 | 2.39 | .63 | 2.67 | .77 | 2.30 | .43 |
| 4 | 2.97 | .87 | 2.54 | .63 | 2.46 | .68 | 2.17 | .59 |
| 5 | 3.58 | .95 | 2.90 | .70 | 2.93 | .86 | 2.81 | .44 |

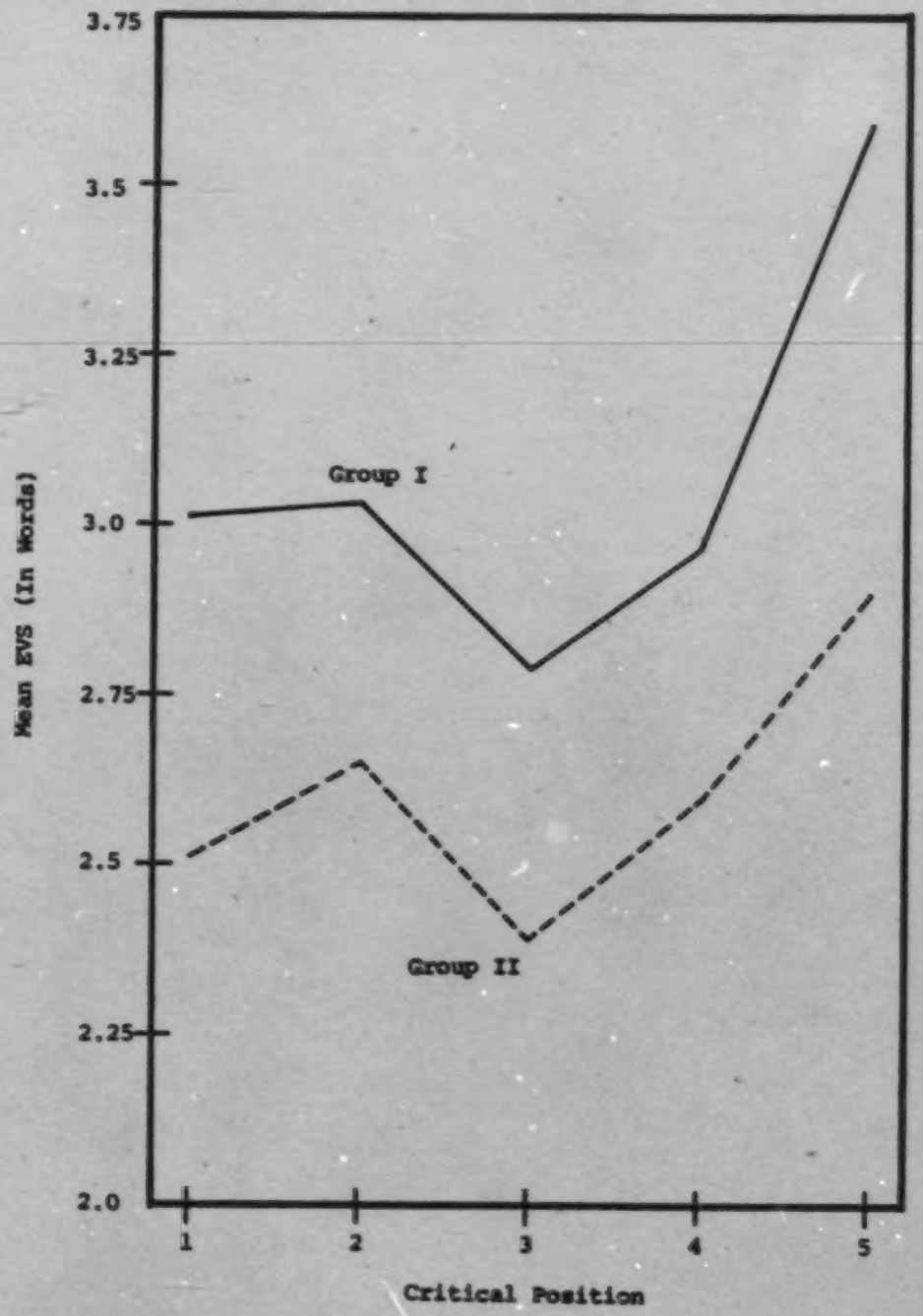


Figure 3. Mean EVS For Right-Embedded Sentences.

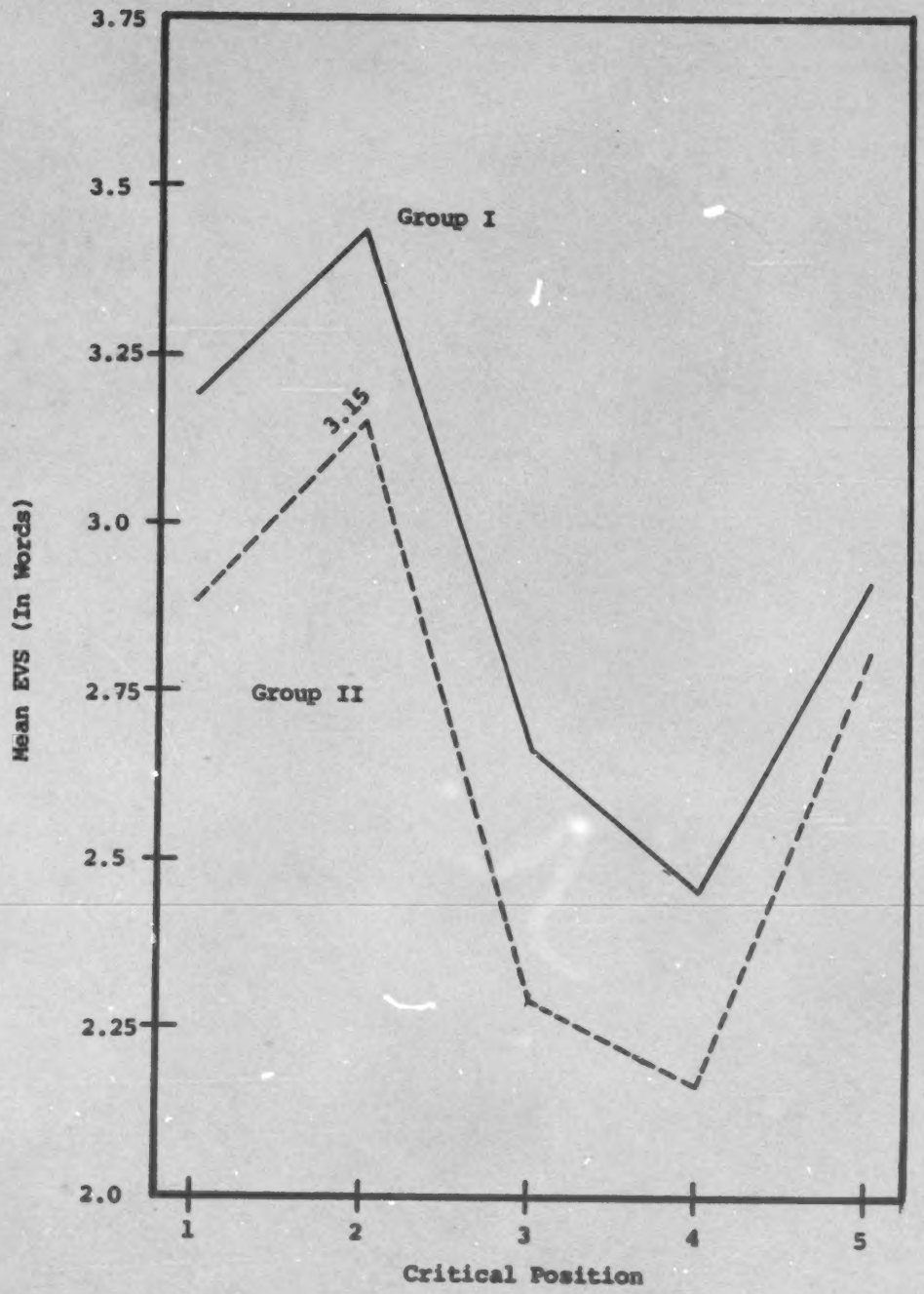


Figure 4. Mean EVS For Left-Embedded Sentences.

## CHAPTER V

## SUMMARY AND CONCLUSIONS

Results from the present study strongly supported arguments for the psychological reality of syntactic chunks, a phenomenon which had been previously demonstrated by several studies utilizing an eye-voice span methodology similar to that used in this experiment and by several studies using speech processing methodologies. Readers apparently used the surface structure of the material undergoing decoding as an aid in processing.

### Hypothesis 1: EVS Termination at Phrase and Clause Boundaries Versus Chance

Under the assumption that eye-voice span reflects internal processes during reading, it was found that readers tended to decode by using surface syntactic constituents. In sentences composed of three-word phrases and clauses, readers in both the better and poorer reading groups tended to stretch or contract their eye-voice spans to the boundaries of phrases and clauses to the extent that almost twice the number of eye-voice span terminations ended at syntactic boundaries as would have been predicted by chance occurrence alone. Such findings indicated that syntactic units play a powerful role in the decoding process.

This phenomenon of boundary reading was significantly present at all critical "light-out" positions taken together, and at the four later critical positions for each group. It was not significant at Critical Position 1 for either group. Position 1 was located at the third word in each target sentence, the closest of the five positions to the left margin of the reading selection. This study was not designed to investigate any cause of the drop in significance, but it may be conjectured that the movement of the eyes across the page and down a line in the return sweep may be slightly disconcerting to the reflection of syntactic analysis by the eye-voice span. It may also be noted from Figures 3 and 4 that the return sweep did not apparently disturb the length of eye-voice span at Critical Position 1 to any great extent, as average length is even shorter at Positions 3 and 4.

## Hypothesis 2: EVS Terminations at Phrase and Clause Boundaries, High Versus Low Readers

High ability readers at the tenth grade level utilized surface phrase and clause constituents significantly more effectively than low readers, as indicated by the mean percentage of EVS terminations at all positions. This hypothesis was based on findings by Rode (1974) that the third grade subjects in her study were superior to the fifth grade subjects in the number of phrase boundaries at which EVS terminated. Rode explained this by arguing that the older readers tended to utilize larger syntactic structures in decoding: "This would seem to indicate that older readers attempt to decode or 'chunk' a unit of meaning which was a clause rather than a phrase"

(p. 137). It was assumed by the author that high school students of both high and low reading ability would be equally adept at utilizing the simple three word phrase and clause structures of the target sentences, though they would probably differ in ability to deal with more complex structures.

However, there was a significant difference in the utilization of these very simple phrase and clause structures between high and low readers. Results indicated that different types of syntactic units result in different percentages of terminations at syntactic boundaries in Groups I and II. As seen in the sample target sentences below, Critical Positions 1 and 2 were both located in simple, three word prepositional phrases. Critical Position 3 was the first word in a verb phrase in the right-embedded sentences and the first word in a relative clause in the left-embedded sentences, and was in both cases preceded by two prepositional phrases. No difference was found between Group I and Group II for these three critical positions. Both better and poorer readers at the tenth grade level were equally able to deal with short prepositional phrases, and to group them into syntactic units.

Right-embedded: During last summer my nearest neighbor

Critical Position: 1 2

grew garden vegetables which won prizes at the fair for

3 4 5

their size.

Left-embedded: Before the storm the old captain who

Critical Position: 1 2 3

was lame sailed his ship past the lighthouse into a port.

4 5

Differences between the sample groups developed at Critical Positions 4 and 5. In the right-embedded sentences, Position 4 was located at the end of the verb phrase and Position 5 at the end of the relative clause. In the left-embedded sentences, Position 4 was at the end of the relative clause and Position 5 at the end of the verb phrase following it. Evidently the low readers had greater difficulty with syntactic organization of the verb phrases and relative clauses than did the high readers. A similar finding was discussed by Rode (1974), who found that younger readers had constricted eye-voice spans in verb phrases.

## Hypothesis 3: EVS Length, High Versus Low Readers

That high readers have longer eye-voice spans than low readers has been a virtually unchallenged concept since the inception of use of the EVS technique. The present study utilized right- and left-embedded sentence structures to test eye-voice span and supported these findings. Better tenth grade students averaged almost one-half word longer eye-voice spans than poorer readers on both right- and left-embedded sentences. The difference in the length of EVS of the high and low readers was statistically significant.

It might be noted here that the mean eye-voice spans for these two groups cannot be generalized beyond the very specific sentence structure types used in the study. The construction of the target sentences was accomplished according to the specifications that each sentence be entirely composed of three word phrases in a specified order. Such a peculiar construction could not but be expected to influence eye-voice span length, especially in the light of literature reviewed that strongly suggested that eye-voice span and eye movement in general are significantly affected by syntax.

Hypothesis 4: EVS Length and Predictability

Results did not support the experimental definition of predictability as applied to right- and left-embedded sentences, though a definite interaction between the two different types of sentence structures and eye-voice span was apparent.

It was expected that EVS length would be similar at the beginning of the sentences (i.e., Critical Positions 1 and 2) for both right- and left-embedded sentences. Then at Critical Positions 4 and 5, which were located inside of and after the embedding, the mean EVS length for the more predictable right-embedded sentences would become significantly longer than for the left-embedded sentences, thus making the overall mean EVS for right-embedded target sentences longer than for left-embedded. A significant overall difference was not found, however.

The results might best be discussed with regard to the individual Critical "light-out" Positions: A. Critical Positions 4 and 5; B. Critical Positions 1 and 2; and C. Critical Position 3.

A. Critical Positions 4 and 5 (region of embedding and verb phrase). As hypothesized, the more predictable right-embedded target sentences obtained longer eye-voice spans than did the left-embedded in the region of the embedded clause and of the verb. Apparently, the eye-voice span is related to the difficulty or predictability of syntactic structures, even to the point of being significantly different when encountering structures which are only slightly different, such as right- and left-embedded relative clauses. If this is so, then eye-voice span can indeed be used as a tool to investigate internal syntactic processes.

B. Critical Positions 1 and 2 (region of introductory prepositional phrases). The results, unexpected though they were, clearly indicated that subjects' eye-voice spans were longer in left-embedded (i.e., those hypothesized as being less predictable) sentences than in right-embedded (i.e., those more predictable, according to the hypothesis) in this region, despite the fact that this introductory region had identical syntactic structure in both types of sentences. As a result, longer eye-voice spans for left-embedded sentences in this region balanced out the longer eye-voice spans for right-embedded sentences in the later part of the sentence, and tests of significance showed no difference between right- and left-embedded EVS length on an overall basis.

Why this phenomenon was not reported in the Levin, Grossman, Kaplan, and Yang (1972) study can only be conjectured: This previous study had used only 10 subjects, and the findings may have been more tenuous than in the present study. Such a phenomenon might, therefore, have gone unnoticed, especially since six of the eight critical positions utilized in that study were located inside of or after the verb phrase embedding and less attention was given to the beginning of the target sentences.

Results of this study seriously call into question the concept of predictability in right- and left-embedded sentences proposed by Levin and Kaplan (1970) and Levin, Grossman, Kaplan, and Yang (1972). It is apparent that their explanations of the interaction between eye-voice span and predictability (i.e., that greater predictability of sentence structure yields a longer eye-voice span) were either completely inaccurate or overly simplistic as far as their work with right- and left-embedded sentences was concerned.

It is not necessary to explain any of the experimental results by a theory of predictability. Indeed, a simpler explanation would be concerned with placement of the critical "lights-out" positions: EVS tends to be longer in right-embedded sentences when the critical position is to the right (i.e., toward the end) of the sentence, and EVS tends to be longer in left-embedded sentences when the critical position is to the left (i.e., toward the beginning) of the sentence. Thus, the apparent differences in syntactic processing of the two sentence structures as revealed by EVS techniques, which previous researchers used to support the concept of predictability, have not

been shown to be real differences, but are rather due to an inadequately designed study.

However, while the explanations of previous experimental results may have been in error, it is not yet necessary to abandon testing of the relationship between predictability and EVS. Perhaps former explanations were correct in their general approaches to the topic, but were too simplistic in application. The hypothesis that greater predictability (in the experimentally defined use of that term) will yield a longer EVS has been demonstrated to be in error, but it may well be that predictability of structure and EVS interact in a more complex manner. For instance, results from this study can be explained in the following way: Readers encountering a less-predictable (left-embedded) structure at the beginning of a sentence increase EVS in order to be able to utilize a larger part of the sentence to analyze the meaning of that structure. Then, at the end of the sentence, EVS is decreased while the actual semantic analysis of the more difficult first section is carried out. On the other hand, readers encountering no difficult, less-predictable structure at the beginning of right-embedded sentences do not find it necessary to lengthen EVS in order to aid analysis of the sentence. Indeed, toward the end of the sentence they are encouraged to increase EVS after encountering the more-predictable, easily decipherable right-embedding. Thus, left-embedded sentences obtain longer EVS at the beginning, and right-embedded sentences obtain longer EVS at the end.

Until research designed to further analyze the predictability of right- and left-embedded sentences is carried out, all explanations

of this phenomenon must remain conjectural in nature. At this time, the literature does not offer any concrete explanation, and the present study was not designed to provide any answers to that facet of the problem.

C. Critical Position 3 (for left-embedded, region of the embedding; for right-embedded, region of the verb phrase). No significant difference was demonstrated at this critical position between the right- and left-embedded sentences, though eye-voice span was a little longer in the left-embedded target sentences than in the right. This position might be considered a transition position between the greater predictability for left-embedded sentence beginnings and the greater predictability for right-embedded sentence endings.

### Hypothesis 5: EVS Length, Adjustment Between Critical Positions, High Versus Low Readers

It was hypothesized that the high reading group would utilize significantly different strategies when dealing with the two different sentence types, whereas the low readers would be relatively inflexible in dealing with the different syntactic structures. This hypothesis was not substantiated. There was no statistically significant difference in amount of adjustment between critical positions in the EVS of Group I and Group II.

Figures 3 and 4 clearly indicated that, while greatly differing strategies are used for dealing with the different sentence types, the two groups of subjects used almost parallel strategies in dealing with the same sentence structure. The mean eye-voice span of the low

readers was somewhat shorter than that of the high readers, but both sample groups apparently adjusted their eye-voice spans in the same manner when dealing with the same syntax.

It is apparent that a great deal of further research must be carried out in this area in order to gain a clearer understanding of the results. Certainly, as discussed under Hypothesis 4, there is an indication that right- and left-embedded sentences may be processed differently, as demonstrated by the greatly variant EVS readings for the two types of sentence structures. If this is so, and the EVS is actually a reflection of the internal processes necessary to deal with syntactic constructions, further studies should be aimed at finding out more exactly the meaning of shifts in EVS length in sentences.

Furthermore, the indication that right- and left-embedded sentences are processed in parallel fashion by tenth graders, regardless of reading ability, merits further investigation. Indications from the present study suggested that better and poorer high school readers utilize syntax in parallel fashions, possessing qualitatively the same attack skills in dealing with syntactic constructions and differing only in quantitative degree of expertise in utilizing these skills. Further research is necessary, especially at lower grade levels and with other types of syntactic constructions, if a more comprehensive understanding of syntactic processes is to be gained.

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# APPENDIX A

## READING SELECTIONS

## APPENDIX A

## READING SELECTIONS

All reading selections were labelled numerically and according to sentence structure of target sentence, RE for right-embedded and LE for left-embedded. In the following list, the target sentence is noted according to the line in which it occurs. Original margins are indicated by slashes.

RE 1 Line 3

Every year a great many tourists go to Paris, the capitol of France. Less than 100 years ago passenger pigeons were/ seen all over the eastern United States. The streets are filled with shops where dresses, hats, gloves, shoes and/ jewelry are sold. After the dance the cleanup crew found many items that were lost under the seats in the gym./ Nobody enjoys playing with a man who lacks control. There is no coal nearby; it must all be shipped in.

RE 2 Line 3

Passenger pigeons no longer exist because so many of them were killed for food. Good players know that it is/ useless to wallop a ball with full strength because they can't control it if they do. I'm fine, how about you?/ Until last year Mr. Anthony Thomas often visited relatives who lived overseas in the capitol of West Germany./ He never knows where the ball is going. The people of other cities

in the world are pleased whenever they are told/ that their city is like Paris.

RE 3 Line 2

Peat is a kind of fuel, made from mosses and other plants that grow in bogs. Some kinds of penguins are larger than/ others. After being fired the discontented worker threatened a foreman who was standing near the gate of the factory./ Nearly all of them make the same mistake he does, but to a lesser degree. The way to beat your friends--and the/ way to enjoy tennis--is to hit a medium-paced ball, with control. There are peat bogs in the United States.

RE 4 Line 2

America has so much coal that peat is not used as fuel. Before hitting the ball, remember to hit it more slowly than/ usual. Without another word my twin brother slammed the door which led outdoors to the garage behind our house./ The earliest white settlers in the Pennsylvania country were Dutch, Swedes and Finns. In 1787 Pennsylvania entered/ the Union as the second state--next after Delaware. I felt like breaking my racket across my knee.

RE 5 Line 2

Pennsylvania ranks first in the making of iron and steel. Philadelphia is the fourth-largest city in the United/ States today. Before Christmas day almost every family donated old toys which were usable to poor children in the city./ Let's see how he is able to do that. Never delay in getting away from the sideline. For almost 200 years

after the/ founding of Jamestown, Americans lived only along the Atlantic coast. The first pioneers were explorers.

RE 6 Line 3

Assume that your shot will be in, and start walking into position for the next return. Most of the land between the/ mountains and the Mississippi River was forest land. Once you do go to the net, it is more important than ever to/ stay awake. As with Fords most modern cars need an adjustment which helps mileage within one year after being purchased./ Too many a player stands flatfooted while his opponent is starting his swing. Mars looks like a red star.

RE 7 Line 2

Mercury travels faster than any of the other planets. Another secret of anticipation in tennis is to keep your eye/ on the ball. Underneath the bed the hungry cat trapped a mouse which had crawled up the stairs from the cellar./ One idea about the straight lines seen on Mars is that they are wide bands of plants growing along water channels./ If a person could visit all the planets he would find that he would weigh much more on some of them than on others.

RE 8 Line 2

One idea about the straight lines seen on Mars is that they are wide bands of plants growing along water channels./ After the accident all police officers wore the uniforms which were marked with fluorescent stripes for high visibility./ You may think you always watch the ball in tennis, but probably you don't. Why should anyone

go to all the trouble/ of writing another book on archery? The electric eel is a fish, not an eel at all.

RE 9 Line 3

Practically every book on tennis ever written has been aimed at readers who want to become champions. When gold was/ discovered in California in 1848, silver became more valuable than gold for a short time. Nobody seems to have much/ to say. Without saying goodbye the angry husband left the woman that he loved after the argument about their budget./ All they want to do is have fun, and beat their own friends at bridge. A house in France is built somewhat/ differently than in Germany.

RE 10 Line 2

The hummingbird is the only bird that can fly backward. In 1249 AD, an Egyptian sultan died from sitting on a poisoned/ floor mat. In the tree tops the distant birds sing sweet songs which are heard by the workers in the fields./ You will find a lot of advice in this book. Don't try to follow all my advice at once. Keep concentrating on two/ or three ideas until they become habits. Many other animals would go hungry if it were not for rabbits.

RE 11 Line 2

Let's not be unhappy about this. While you're on the tennis court, you should be enjoying life. Rabbits eat only/plants. After three weeks two German armies attacked American troops who were staticned near the town of Saint Martine./ Some reasons are good, some not

so good. If you take up bridge to make new friends, play the game fairly. German/ bombers were doing great damage to English cities, but then radar began to be used to spot enemy planes.

RE 12 Line 3

It's a polite, friendly game. There are several breeds of tame rabbits. Radar waves travel as fast as light./ Over a period of years tennis will convert blubber into muscle, perhaps, but it won't change your weight noticeably./ With some exceptions many competitive sports demand great exertions which are dangerous to the health of the players./ If you want to be popular, you'll always keep tennis a game, not a fight.

RE 13 Line 2

Radar waves are very short radio waves. Besides oats, Scotch farmers raise some other grains and some vegetables and/ small fruits. From the East the tea ships carried the leaves which were desired by all families in Western Europe./ The word "science" comes from the Latin word meaning "to know." If you are looking for quick changes, look some-/ place else. Don't make work out of something you should be enjoying. Winning or losing isn't the important thing.

RE 14 Line 3

Most doctors I know say that if you want to lose weight, the best way to do it is to eat less food. Sports tone you/ up, make you sleep better and eat better and feel friskier during the day. Smacking the ball with all your might/ is stupid. During last

summer my nearest neighbor grew garden vegetables which won prizes at the fair for their size./ Learning to play good tennis is pretty much the same as learning to typewrite or to bake cakes. During the later/ Middle Ages universities sprang up in many cities of Europe.

RE 15 Line 2

In the early days of America almost all the schools were private schools. Anyone can do it, if he is given instructions./ Throughout all history few great nations have helped people who were defeated after a war against those people./ Some people will become faster typists or better bakers than others, but nobody will fail completely. The first/ schools in America were held in buildings built for other purposes. The driver who missed his turn hit the brakes/ violently.

RE 16 Line 3

All over the United States the robin is likely to be the first bird children know by name. Almost everyone has/ wondered at times about questions like these. The mother robin lays from three to five beautiful eggs in the nest./ Among African tribesmen the powerful witchdoctors cure the sick who are possessed by evil spirits from the jungle./ How can pets be trained to do tricks? One of the most common questions is "How does it work?"

RE 17 Line 3

Doctors are finding more and more that the mind and the rest of the body are very closely tied together. Employers/ are able to place the people they hire in the kinds of jobs best for them. The Romans

planted many colonies through-/ out central Italy. Like most doctors our local doctor has some patients who are ill from the effects of eating improperly./ Some chemicals change when light strikes them. Everyone needs to know something about physics.

RE 18 Line 2

Most of today's pictures are taken on film--thin sheets of transparent plastic. Photography is a wonderful hobby./ Since the hurricane stores and factories have resumed business which was interrupted by the devastation of the storm./ Before the days of science people in many different parts of the world made up stories to explain the world as they/ saw it. The Romans opened schools and made educated Greek captives the teachers. There are many Indian legends/ about nature.

RE 19 Line 2

Before the picture is taken, the photographer focuses the lens of his camera so that the image on the film will be/ clear. During the vacation the Smith family visited their relatives who were living near Lake Erie in New York./ For ten years Caesar had fought to push the border of Rome's empire to the north. The more light that passes/ through the negative the more the chemical on the paper is changed. The hunter climbed to the top of the mountain.

RE 20 Line 4

The film that is used for moving pictures is the same as the film for ordinary pictures. There they found a land of/ flowers and

birds and summer weather. Two peaceful centuries followed. Some emperors were cruel, overtaxing the/ people till farmers and merchants suffered. The broken bits of the western empire became the modern countries of/ West Europe. Between the mountains the rolling river cut a pathway which ran directly from the east to the west./ The birds flew out and up to the sky. Light meters tell how much light is available for taking pictures.

LE 1 Line 2

The Soviet ambassador insulted American ideas, but he praised the Cuban government for its actions. Microwave/ cooking saves much time. In the yard the huge dog which was chained howled its anger at the cars on the road./ The townspeople did not realize that he only appeared to be the famous doctor. Fire towers dot the hillsides, the/ rangers inside being very careful about forest fires. If a child speaks in her presence, she appears insulted./ Research chemists are hired by almost every chemical factory to search for new ideas.

LE 2 Line 2

Both children and parents have chores to do. Today is my birthday, but my family will have a party for me on Sunday./ After the earthquake many unfortunate victims who were hurt requested some help from rescue workers at the scene./ The schools were closed because of the dangerous snowfall. She hurried into her history classroom and sat/ down, opening her book for last minute studying. At the sound of the fire alarm, everyone left the building/ immediately.

LE 3 Line 2

His books went flying all over the hall as another student ran into his arm. The girl was cut on the finger./ Across the country most small diners that sell hamburgers lost many sales to McDonald's restaurants during the sixties./ His look of cold hatred was very insulting. If you finish the homework by six o'clock, you may go outside to play/ baseball. The color scheme of a room should be decided upon before any painting begins.

LE 4 Line 3

Decorative stones or shells may be added to complete a fish tank. Leisure time is a precious gift. Today/ tennis is a sport for both males and females of all ages. When I go to college, I'll begin studying hard, but now/ I will take it easy. After the class most of us who had attended enjoyed a meal at the diner near the school./ Changes in clothing styles have made tennis easier and more comfortable to play.

LE 5 Line 2

Chemistry teachers stress the use of a scientific method when doing experiments. I patted her shoulder and went to/ prepare supper. Along the river the fine homes which were flooded cost their owners over ten million in repair bills./ A person's first impression of another may be very wrong. Students who participate in the Student Council often/ have a great deal to say about how the school will be run. Every girl would like to be rich and have luxuries./ We all love and care for her, since she is so special to all of us.

LE 6 Line 2

The whole mountainside was lit up in an attempt to see any start of a new rockslide so that people might run for their/ lives. During the concert the famous violinist who was drunk dropped his instrument onto the floor with a crash./ Many good looking people have very poor personalities. Peter complained that his poor marks were a result of/ inability to do his homework when his younger brothers were making noise.

LE 7 Line 2

The miners worked hard chopping away at the rock. He doesn't take his work very seriously. Time limits on tests are/ short. From a mountaintop an ordinary person who looks around can see sights beyond the expectations of most people./ Useless ideas must be left out of term papers in order to obtain a good grade. A million dollars is more money than/ I'll ever see. The crime rate is serious in the dark streets of the inner city. The homework will be done by/ tomorrow morning.

LE 8 Line 3

Advertisers think they know exactly what the public wants. The school play involved several costume and set changes./ My enemies have ignored the serious problems our city faces. June 6, 1944 saw a vast Allied fleet sailing off the/ French coast. Despite his weight a football player who is fit runs a mile within ten minutes without much trouble./ A vital task of the newspaper is to report news

correctly, even if that may bother readers. Mystery novels often/ keep me reading long into the late night hours.

LE 9 Line 3

The rescue squad will collect donations tomorrow. Millions of dollars are spent each year on magazine advertisements./ A fairly new development, color photography has only been in existence for forty years. Microwave cooking saves/ time. During his training a ballet dancer who is dedicated exercises his body for long hours despite his weariness./ Diamond jewelry is expensive, but a diamond never loses its value. The dictionary, a valuable tool for writing,/ has much in it besides definitions. Airlines today go to all corners of the world.

LE 10 Line 2

Florida, a favorite vacation spot, is only hours away by plane. The fastest growing sport in America today is tennis./ Like many Christians most Mexican citizens who are religious attend their churches every single Sunday of the year./ The effect of the drug was proved by tests. After the attack, Israel was accused of ignoring the law. Full-time/ pianists have undergone years of practice. Because no female actors were allowed on the stage in Shakespeare's/ time, boys played the parts of women.

LE 11 Line 2

Good grades are necessary to become a scientist. We waited until the sun had risen before we went back home./ Beyond the hills the

great desert which lies westward stretches its sands to the shores of the ocean./ Some biologists work on different ways to improve the environment. After an early supper, we drove to the/ theater and arrived with plenty of time to spare. Everyone who chooses a career should be aware of all aspects of it.

LE 12 Line 2

In the weeks after Pearl Harbor, the nation quickly made itself ready for war. We shall have to go without Mark or/ her. In the summar the many people who enjoy swimming mob the beaches in great numbers during their vacations./ When our shortstop is at bat, the opposing team members play deep. Girls like Joyce and Carol are always well/ groomed. The coolest part of the day is the early morning hours. It was to him and me that this letter was/ mailed, but neither of us received it.

LE 13 Line 4

Camping tents can be made of lightweight materials, often weighing no more than two or three pounds. Because of/ a last minute effort, the home team finally won the game. It never fails to rain when the wash is hung out to dry./ I've known Alex for as long as I can remember. She said that she would join us if she were invited, and she did/ so happily. In the ambulance the injured man who was conscious screamed his fears of further injury by a car./ No one can predict the future, but we can make some good guesses about it. No one was home in the cottage.

LE 14 Line 3

Back at his hotel, he found the reporters waiting to interview him. It was only a few days before her death that/ she told me to go to a desk in her house and open a secret drawer. There seems to be something written on this/ scrapbook. Between the trees the little deer which was orphaned nibbled the grass until the night with its dangers./ There were fabulous sunsets, as well as beautiful skies at night, filled with stars and rimmed with snowy mountains.

LE 15 Line 2

My father called Paul and me together. Everyone who passes the entrance examinations may begin college work in/ September. During the film most people there who sat forward missed the argument in the back of the theater./ Why don't you send John and me copies of this photograph? The fruit from our garden is enough to support the entire/ family for most of the winter. We call Fred, John, Paul and Marty the "Fantastic Four."

LE 16 Line 3

From the top of the mountain, one can see for miles around. Tell us what the story is about or we won't listen./ Just because the facts disagree with me is no reason for me to change my mind. We mocked the team as they came out/ on the field. After the pitch the baseball runner who had singled dove toward second without a hope of reaching it./ Most people agree that it is wrong, but many will do it anyway. Have you seen them doing it?

LE 17 Line 2

Roberto Clemente, the well-known baseball player, was killed in a plan crash. Three-leaved plants may be poison ivy./ In the meantime the speed skater who had fallen raced once more against his opponent from Central Europe./ Mark Twain was a young man when he piloted a steamship on the Mississippi River. Many of the raw materials used/ in our factories are imported from overseas. When I meet Jack, he is always glad to see me.

LE 18 Line 4

The crisp newly-fallen snow hung off the branches of the pine trees like huge blankets. Injections to ward off/ disease are now available for almost everything, from mumps to smallpox. Nearly everyone in the audience/ yelled their opinions with harsh boos and hisses. Taxes and the cost of living are rising each month, but paychecks/ are not. Since early January the cold weather which covered Ohio caused icy spots in many places on the roads./ The trees at the top of the hill stood over the rolling valley below.

LE 19 Line 2

The helicopter, first used in the Korean War, may one day become a popular form of transportation for many/ people. At the museum many younger children who wander about see the bones of huge dinosaurs from the past./ There are dozens of books on tennis in our town's library. Don't try to become an expert skier during your first/ day on the slopes. Advanced swimmers can be of great help to anyone who finds himself in trouble in the water.

LE 20 Line 3

When you stop having fun at sports, you will probably stop winning. Keep a song in your heart, and you'll be all/ right. People dislike playing with someone who hits the tennis ball too hard. In Paris there are no tall buildings/ hiding the city. Before the storm the old captain who was lame sailed his ship past the lighthouse into a port./ There must be something else wrong. He never knows where the ball is going to land.

Filler 1

People all over the world have told wonderful stories of their past. The science of physics is partly a study of/matter. Many cities throughout the world still copy the Greek-Roman styles of building. Many legends have some/ truth in them. They are easy to tell apart and each one is useful in its own way. All places of any importance and/ all people have names. The oldest of the national parks is Yellowstone. One city of Canada is far bigger than all/ the others.

Filler 2

It was not surprising that men found natural gas when they were digging for oil. The city gets its name from a high/ hill that rises behind it. When people first looked at the moon through telescopes, they thought that the plains/ were seas. Despite his filthy appearance, the youngster refused to take a bath. The pilots' strike had grounded/ airplanes for three days. Nuclear energy plants may someday provide us with most of our electricity.

Filler 3

Pilots who fly large jets earn large salaries. Scientists are unsure whether air pollution causes the earth to/ become warmer. Many Americans have no knowledge of the location of Bhutan. Eighty-four percent of all American/ roads are country roads. Almost every large American city has at least one museum. When men first began trading with/ one another they needed ways of counting and measuring. Everything in the world is made out of about 100 simple/ substances we call elements.

Filler 4

Most metals do not stay shiny and clean for long when they are exposed to air. The people of long ago made up/ many stories to explain the pictures they saw in the moon. Jupiter was the king of the gods. Each planet has its/ own path around the sun. American porcupines are good tree climbers. The riders carried mail in small leather/ bags. Some people call printing the greatest invention of the past 500 years.

Filler 5

In regions of warm summers and cold winters some animals change their dress with the seasons. In the Middle Ages/ puppets were very popular. When a plant breeder starts work, he has in mind the kind of plant he would like to get./ In the early days of the West the cattle roamed over the plains for most of the year. Field mice do a great deal/ of damage to crops. There are now hundreds of thousands of miles of concrete highways in the United States alone.

## APPENDIX B

## TARGET SENTENCES

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Sentences labelled RE are right-embedded, and sentences labelled LE are left-embedded. Critical "black-out" points are underlined.

RE 1

After the dance the cleanup crew found many items that were lost under the seats in the gym.

RE 2

Until last year Mr. Anthony Thomas often visited relatives who lived overseas in the capitol of West Germany.

RE 3

After being fired the discontented worker threatened a foreman who was standing near the gate of the factory.

RE 4

Without another word my twin brother slammed the door which led outdoors to the garage behind our house.

RE 5

Before Christmas day almost every family donated old toys which were usable to poor children in the city.

RE 6

As with Fords most modern cars need an adjustment which helps mileage within one year after being purchased.

RE 7

Underneath the bed the hungry cat trapped a mouse which had crawled up the stairs from the cellar.

RE 8

After the accident all police officers wore the uniforms which were marked with fluorescent stripes for high visibility.

RE 9

Without saying goodbye the angry husband left the woman that he loved after the argument about their budget.

RE 10

In the treetops the distant birds sing sweet songs which are heard by the workers in the fields.

RE 11

After three weeks two German armies attacked American troops who were stationed near the town of Saint Martin.

RE 12

With some exceptions many competitive sports demand great exertions which are dangerous to the health of the players.

RE 13

From the East the tea ships carried the leaves which were desired by all families in Western Europe.

RE 14

During last summer my nearest neighbor grew garden vegetables which won prizes at the fair for their size.

RE 15

Throughout all history few great nations have helped people who were defeated after a war against those people.

RE 16

Among African tribesmen the powerful witchdoctors cure the sick who are possessed by evil spirits from the jungle.

RE 17

Like most doctors our local doctor has some patients who are ill from the effects of eating improperly.

RE 18

Since the hurricane stores and factories have resumed business which was interrupted by the devastation of the storm.

RE 19

During the vacation the Smith family visited their relatives who were living near Lake Erie in New York.

LE 20

Between the mountains the rolling river cut a pathway which ran directly from the east to the west.

LE 1

In the yard the huge dog which was chained howled its anger at the cars in the road.

LE 2

After the earthquake many unfortunate victims who were hurt requested some help from rescue workers at the scene.

LE 3

Across the country most small diners that sell hamburgers lost many sales to McDonald's restaurants during the sixties.

LE 4

After the class most of us who had attended enjoyed a meal at the diner near the school.

LE 5

Along the river the fine homes which were flooded cost their owners over ten million in repair bills.

LE 6

During the concert the famous violinist who was tipsy dropped his instrument onto the floor with a crash.

LE 7

From a mountaintop an ordinary person who looks around can see sights beyond the expectations of most people.

LE 8

Despite his weight a football player who is fit runs a mile within ten minutes without much trouble.

LE 9

During his training a ballet dancer who is dedicated exercises his body for long hours despite his weariness.

LE 10

Like many Christians most Mexican citizens who are religious attend their churches every single Sunday of the year.

LE 11

Beyond the hills the great desert which lies westward stretches its sands to the sho-es of the ocean.

LE 12

In the summer the many people who enjoy swimming mob the beaches in great numbers during their vacations.

LE 13

In the ambulance the injured men who was conscious screamed his fears of further injury by a car.

LE 14

Between the trees the little deer which was orphaned nibbled the the grass until the night with its dangers.

LE 15

During the film most people there who sat forward missed the argument in the back of the theater.

LE 16

After the pitch the baseball runner who had singled dove toward second without a hope of reaching it.

LE 17

In the meantime the speed skater who had fallen raced once more against his opponent from Central Europe.

LE 18

Since early January the cold weather which covered the Ohio cause icy spots in many places on the roads.

LE 19

At the museum many younger children who wander about see the bones of huge dinosaurs from the past.

LE 20

Before the storm the old captain who was lame sailed his ship past the lighthouse into a port.